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GEOLOGY AND MINERAL RESOURCES OF YORK COUNTY

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GEORGE W. STOSE
AND
ANNA I. JONAS

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BULLETIN C 67

GEOLOGY AND MINERAL RESOURCES OF YORK COUNTY PENNSYLVANIA

By

GEORGE W. STOSE
of the U. S. Geological Survey

and

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Department of Internal Affairs
William S. Livengood, Jr., *Secretary*

Topographic and Geologic Survey
George H. Ashley, *State Geologist*

Harrisburg, Pa.
1939

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GEOLOGY AND MINERAL RESOURCES OF YORK COUNTY, PENNSYLVANIA

By GEORGE W. STOSE and ANNA I. JONAS

GEOGRAPHY

The report on York County describes the geography of the area and the kinds of rock formations which compose it and the mineral wealth contained in these rocks.

Location.—York County is the third county west of Delaware River on the southern border of Pennsylvania and lies west of Susquehanna River, whose western bank is the Lancaster and Dauphin County line. Adams County bounds York County on the west, and the report on Adams County is the first of the series of county reports[1] published by the State Survey. Cumberland County lies northwest of York County. The southern boundary of York County, along the Mason and Dixon line where it adjoins Maryland, is 40 miles in length. Its length along Susquehanna River is 48 miles, and at its northwestern border it is 18 miles wide. It contains 903 square miles. (See Fig. 1.)

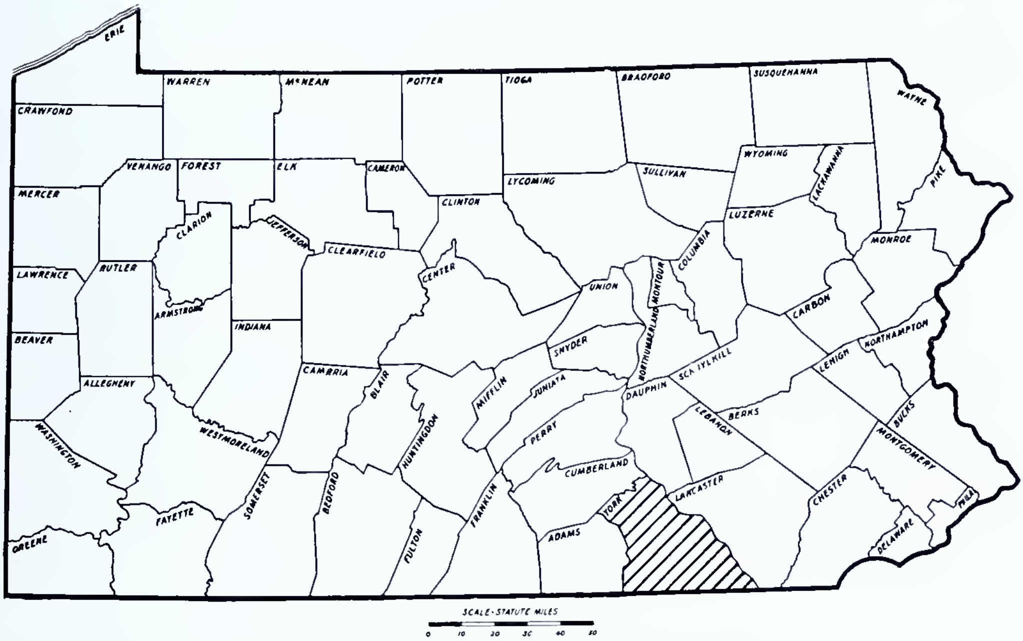

Figure 1. Index map of Pennsylvania, showing location of York County.

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[1] Stose, G. W., Geology and mineral resources of Adams County, Pa.: Pennsylvania Topog. and Geol. Survey, Bull. C-1, 1932.

In March 1681 the Province of Pennsylvania under William Penn was divided into three counties, Philadelphia, Bucks, and Chester. In 1727 Lancaster County was separated from Chester County. At that time there were no settlements west of Susquehanna River. In 1736, at the conclusion of the Indian Treaty, Lancaster County was extended to include a wide area west of the river, and in 1749 York County was erected by action of the Deputy Governor of the Province. The town of York had been laid out 8 years before. The northern boundary of York County was not settled until the erection of Cumberland County from Lancaster County in 1750. At that time York County embraced the present area of Adams County, which was not made into a separate county until 1800.

York county is divided into the following 34 townships:

Carroll
Chanceford
Lower Chanceford
Codorus
North Codorus
Conewago
Dover
Fairview
Fawn
Franklin
Heidelberg
Hellam
Hopewell
East Hopewell
North Hopewell
Jackson
Manchester
West Manchester
Manheim
West Manheim
Monaghan
Newberry
Peach Bottom
Paradise
Penn
Shrewsbury
Springetsbury
Springfield
Spring Garden
Warrington
Washington
Windsor
Lower Windsor
York

Population.—York, the only city in the county, is the county seat, and its population, by the Census of 1930, is 55,254. The boroughs of West York and North York and the recently developed area east of the city are not part of the city, and their population is not included in the above figure. The present population of Greater York, according to the York Chamber of Commerce, is about 70,000. The population of Hanover, the largest borough, by the Census of 1930, is 11,805.

The populations of the other boroughs in York County, as recorded by the Census of 1930, are listed below:

Red Lion 4,757
Dallastown 2,849
Wrightsville 2,247
Spring Grove 1,236
New Freedom 1,125
Mount Wolf 999
Dillsburg 983
Stewartstown 863
Hellam 771
Yorkhaven 770
Delta 762
Dover 676
Shrewsbury 671
Yoe 560
Jefferson 528
Emigsville 516

Other settlements, with populations less than 500, include: Airville, Bittersville, Bridgeton, Brodbecks, Brogueville, Bryansville, East Prospect, Felton, Jacobus, Lewisberry, Loganville, Martinsville, Muddy Creek Forks, Newberrytown, Saginaw, Seitzland, Stevenstown, Strinestown, Smyser, Thomasville, Yorkana, and York New Salem.

The population of York County in 1930 was 167,135, and as settlements containing less than 2,500 people are classed as rural, the Census reports a little over one-half of the population as rural.

Topography

Land forms.—York County embraces parts of the Blue Ridge and Piedmont provinces of the Appalachian Highlands. The northwestern part of the county is occupied by South Mountain, the local representative of the Blue Ridge. It lies just south of Cumberland Valley, which is part of the Appalachian Ridge and Valley province.

The surface forms of the rest of the county are a part of the Piedmont Province and fall into three types—(1) The Gettysburg plain with the Conewago Mountain and the higher hills to the northwest; (2) a well-dissected upland forming the Hellam and Pigeon Hills and another wider upland occupying the southeastern third of the county; (3) a lowland that forms the narrow Hanover-York Valley (Plate 1, in packet.)

South Mountain.—South Mountain is composed of parallel ridges that trend northeastward, separated by somewhat discontinuous narrow valleys. These ridges are formed by hard resistant quartzite and have narrow crests and steep wooded slopes that rise abruptly from the valleys which surround them. Only the southern ridge, which includes Stone Head and rises to 1,460 feet in altitude, and the southern flank of the main ridge north of Dillsburg are included in York County. (See Pl. 2A.) The ridges are separated by a narrow valley formed by limestone that extends northeastward into the wide Cumberland Valley in Cumberland County.

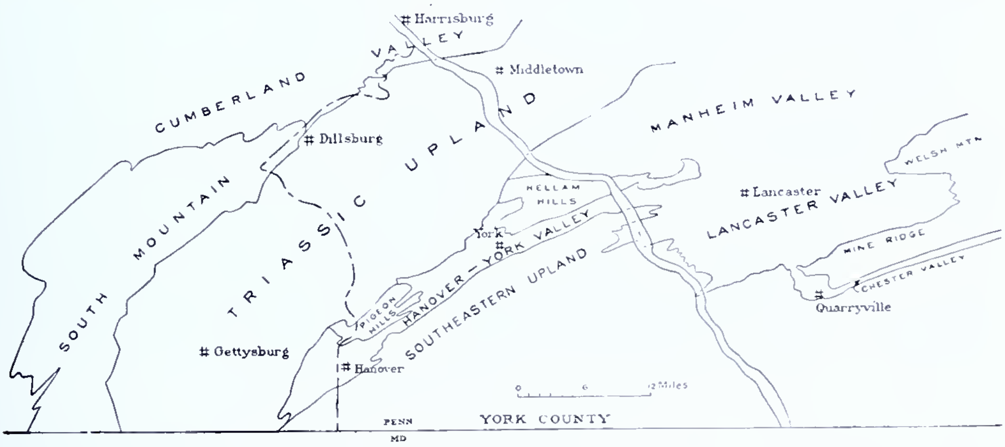


Figure 2. Map of south-central Pennsylvania, showing major topographic divisions.

Gettysburg plain.—Under this title is included the low upland with high knobs and ridges that stretches from the Adams County line northeast to Susquehanna River and lies northwest of the Pigeon Hills and Hellam Hills and a line connecting these hills. The Gettysburg plain is part of the Piedmont Province, but in general its surface is lower than that of the Piedmont upland because of the soft, easily eroded red shale and sandstones that underlie it. In York County some hard and resistant conglomerate beds and large bodies of diabase are so resistant that much of the surface of the Gettysburg plain in York County stands above the general surface of the plain. The general level of the plain is 500 feet, but in places it rises to 600 feet. Its surface is dissected by the streams into low ridges and hillocks that generally trend northeast. Conewago Mountain, composed of harder conglomeratic beds, trends northeast and attains 1,050 feet in altitude. Northwest and north of Conewago Mountain higher ridges and peaks predominate, and reach 1,380 feet in Round Top. Other high sharp-topped peaks are Nells Hill, 1,220 feet; Flat Mountain, 1,130 feet; Pinetown Hill and Blair Hill, 1,120 feet; and Ramsey Hill, 1,100 feet, with lower hills north of Lewisberry. These peaks and other hills and ridges are formed by diabase and baked shale and sandstone that border the diabase, and are in large part rocky and well wooded.

The Hellam and Pigeon Hills.—These hills cross the central part of the county southeast of the Gettysburg plain. They coincide with outcrops of hard quartzites and conglomerates. The Hellam Hills extend southwestward from Susquehanna River to York, and their highest point, 2½ miles west of Highmount, is 1,040 feet above sea level. The ridge just west of Highmount and that south of Glades attain 900 feet, and Roundtop, 800 feet. The Hellam Hills have steep slopes and cliffs along the Susquehanna on the north side and gentler slopes and low foothills on the south and west sides. The westward extension of the Hellam Hills is cut by the deep rocky gorge of Codorus Creek near its mouth. The hills west of the gorge rise to 720 feet in altitude. Just northeast of York the hard rocks of the Hellam Hills plunge under the softer limestones of the York valley, and along the strike 9 miles to the southwestward similar ridges, the Pigeon Hills, rise out of this valley at Nashville. The highest parts of the Pigeon Hills rise 400-600 feet above the limestone valley at Hanover to a general level of 1,000 to 1,100 feet, and attain 1,240 feet in altitude in one peak.

The Hanover-York Valley.—This valley crosses the country from Wrightsville, at the river, southwestward through York and Hanover. Northeast of York it is a limestone valley about 2 miles wide, with a floor 420 feet in altitude, into which a tributary of Kreutz Creek has cut a shallow valley in the vicinity of Hellam Station. Codorus Creek crosses it a York, southwest of which city the valley expands to about 4 miles in width as far as the northeast end of the Pigeon Hills at Nashville. In this wider part many low shale hills, over 500 feet in altitude, rise out of the limestone lowland. Southwest of Nashville the valley is constricted again to 2 miles in width between the Pigeon Hills and the southern upland. The limestone valley in the vicinity of Hanover expands again to 4 miles in width and is nearly flat, with an altitude of about 600 feet. The elevation of the valley floor therefore, rises southwestward away from Susquehanna River, where the general level is about 300 feet and Kreutz Creek at its mouth has cut down to 180 feet above sea level in the limestone floor.

The southeastern upland.—This upland covers the southeastern third of the county and extends southwestward from the Susquehanna River, and borders the Maryland line to the southwest corner of the county, 3 miles south of Hanover. The rocks in this upland are largely schists and quartzites which resist erosion. The highest part of this upland forms an irregular ridge which passes through Red Lion, Rinely, Shrewsbury, New Freedom, and curves westward near the Maryland line to West Manheim township. In the vicinity of

A. Northeast end of South Mountain, northwest of Dillsburg.
Seen from the south.

B. Chickies Rock Gap and Pennsylvania Railroad bridge, at Wrightsville.
As seen from the south before the bridge on Highway U. S. 30 was built.

Red Lion the summit of the ridge is over 900 feet, attaining 1,000 feet at a point east of Yoe. The divide is mostly below 900 feet to Winterstown, but southward as far as Shrewsbury it has a broad top over 1,000 feet in altitude. At Mount Olivet Church one sharp hill rises to 1,080 feet. South of Rinely the north and south direction of the central divide changes to westerly and southwesterly, and this east-west-trending ridge is the divide between the waters of Codorus Creek, which flows north, and of Deer Creek and Gunpowder Falls and its tributaries, which flow southeasterly. The Harrisburg division of the Pennsylvania Railroad crosses the divide at Summit Grove, just south of New Freedom, through a low gap at an altitude of 840 feet. West of South Branch of Codorus Creek and of Glen Rock, which is located in the valley of that creek, there is a series of parallel ridges trending southwestward with a general elevation of 1,000-1,100 feet. Rocky Ridge, the highest peak in the southeastern upland, parallels Dug Hill and other ridges of slightly less elevation. From Huntrick Hill southwest to West Manheim township there is a dissected upland from 900-1,000 feet in elevation.

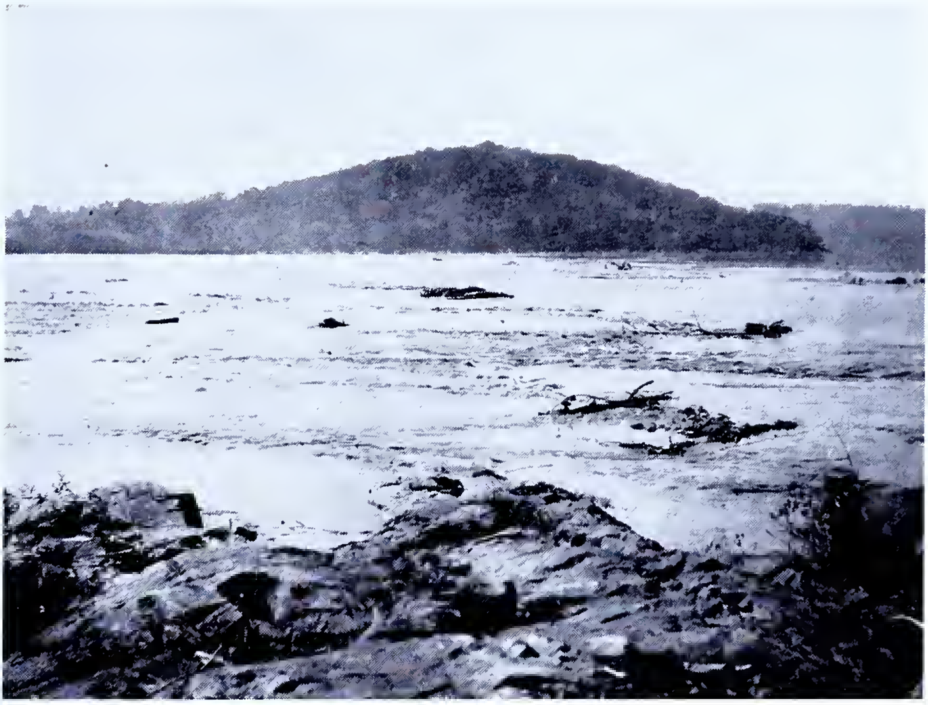
Northwest of this central divide the upland slopes northwestward to the Hanover-York Valley where it terminates abrutly at an elevation of 700 to 900 feet along a line that extends parallel to the boundary between the quartzose and schistose rocks of the upland and the limestones of the valley.

East and southeast of the divide the surface slopes gently toward Susquehanna River. A small valley area near Susquehanna River, drained by Canadochly and Cabin Creeks and underlain by limestone, occurs in the northeastern part of the upland, and the streams here have cut down to 240 feet altitude in the limestone floor. Southeastward the general summits above the river are 600 to 700 feet in altitude to Slab, and farther southeastward the level is only 400 feet. Along the river the hill slopes descend rapidly to the water surface, which is 227 feet altitude near Wrightsville and 70 feet at the Maryland line.

Drainage

York County is drained largely by Susquehanna River and its tributaries, but several streams belonging to the Chesapeake drainage head in the southern part of the county.

Susquehanna drainage.—The Susquehanna River borders York County on the east from the Cumberland County line at the mouth of Yellow Breeches Creek southeastward to the Maryland line. The county boundary lies along the western bank of the river. Four large streams cross York County and empty into the Susquehanna, namely—Yellow Breeches Creek, which forms the northwestern boundary, Conewago, Codorus, and Muddy Creeks. Several smaller streams, including Kreutz, Canadochly, Cabin, Fishing, and Otter Creeks, also flow eastward into the Susquehanna in the county. It is interesting to note that the name Canadochly is taken from the Indian name, Cannodaghtoh, a king of the Susquehannock Indians.



A. Hill Island, composed of Triassic diabase.

Riffles in the river produced by resistant Triassic shale baked by the diabase intrusion. Looking west across the river.

B. Haldeman Riffles, Susquehanna River.

Made by ledges of a diabase dike which crosses the river to the mouth of Codorus Creek. Looking south, across river.

The Susquehanna from its source in Lake Otsego, N. Y., to the head of Chesapeake Bay is 422 miles long, and it drains an area of 27,400 square miles. The portion of the river that borders York County lies between points 65 and 17 miles north of its mouth. The word "Susquehannock," meaning "dwellers at the falls," was first heard by Capt. John Smith, and was the name of the Indians, a tribe of the Iroquois, that lived along the lower part of the river from Harrisburg to Octoraro Creek. Another interpretation of the word Susquehanna is "the stream that falls towards the south." Frazer[2] states that it means "river of islands."

In 1672, after a twenty years war with the Five Nations of New York, the Susquehannocks were nearly annihilated and driven into Maryland and Virginia. Opposition to their presence in these areas by the Indians already there resulted in the Indian War of 1675.

The islands of the Susquehanna, the areas near the mouths of its chief tributary streams, and the terraces along the river, especially those on the Lancaster side east of Long Level, have yielded Indian pottery and implements, including besides flints and tomahawks, small images closely resembling those of the Aztecs, some of which are preserved in the museums of Lancaster and York. Along the Susquehanna River have been found village sites once occupied by the Conestoga Indians. Eighty-nine complete pottery vessels and many other every-day possessions of this extinct tribe have been unearthed by G. B. Fenstermacher, of Lancaster, in cooperation with the State Museum at Harrisburg. Captain John Smith, who first encountered the Conestogas in 1608, described them as being warlike and far superior in physique to other neighboring tribes. Yet they were conquered by the Iroquois Indians in 1675, and less than a hundred years later the twenty warriors that were the only remnants of the once powerful tribe were massacred by white men, at Lancaster, Pa. Growing interest in Pennsylvania's prehistory has lately aroused the State Legislature to appropriate $20,000 to the Historical Commission for the purpose of conducting researches within the State.

From the number of spears, arrows, and sinkers found near the river it is clear that the Indians derived a large part of their food supply from the river. Kitchen-middens near Washingtonboro, mentioned by Roddy,[3] containing mainly shells and fish bones, bear out this suggestion. Roddy (p. 67) describes the Indian implements and their probable use in fishing by the Indians. The Indians also left sculptured inscriptions on rocks in the river opposite Safe Harbor, some of which appear to be crude drawings of fish.[4] These are similar to those at Bald Friar, Maryland.

Between the mouths of Yellow Breeches and Codorus Creek the fall of the river is 4 feet per mile. In this part the river is crossed by

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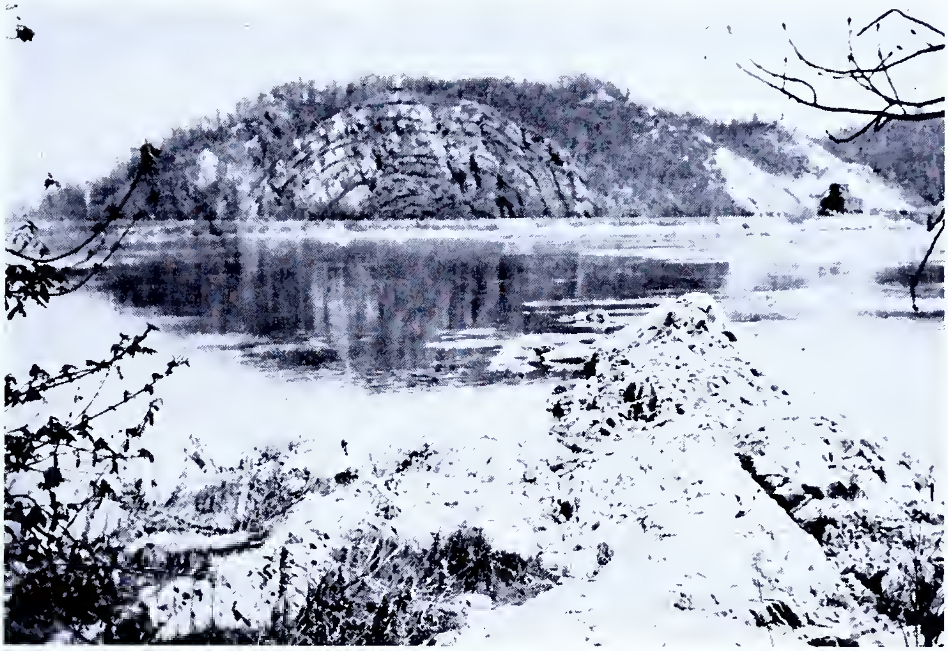
[2] Frazer, P., Jr., Lancaster County, Pennsylvania 2d Geol. Survey C-3, p. 91, 1890.

[3] Roddy, H. J., Physical and industrial geography of Lancaster County, Pa., p. 66, 1916.

[4] Frazer, P., Jr., op. cit., p. 61, and Pls. I-III, pp. 94-95, 1880.
Cadzon, Donald A., Petroglyphs (Rock Carvings) in the Susquehanna River near Safe Harbor, Pennsylvania: Pa. Hist. Comm., Vol. III, Safe Harbor Report No. 1, 59 pp., 1934.
————————, Archaeological Studies of the Susquehannock Indians of Pennsylvania: Pa. Hist. Comm., Vol. III, Safe Harbor Report No. 2, 217 pp., 1936.



A. Chickies Rock.
An anticline of Chickies quartzite; ledges of quartzite at Hellam Point in foreground and make riffles in river.

B. Hellam Point.
View looking west from Chickies Rock.

riffles which reflect resistant rocks at those points. The riffles at Hill Island (Pl. 3 A) and Conewago Falls, just north of the mouth of Conewago Creek, are formed by baked Triassic shale; Haldeman Riffles (see Pl. 3 B), located at the mouth of Codorus Creek, is at the crossing of a diabase dike. Where the river passes through the ridge formed by Hellam Hills, York County, and Chickies Rock, Lancaster County (see Pls. 2 B, 4 A, 4 B) the stream flows over ledges of quartzite that form rapids in a channel only 0.3 mile wide. The channel broadens southward, where it is largely in limestone and is 2 miles wide at Long Level. Southeastward the river flows in a narrow gorge produced by the hard rocks of the southern upland. Its gradient south of Long Level is 6 feet to the mile. Its narrowest point lies just north of the mouth of Oakland Run and north of McCalls Ferry, Lancaster County, where the stream is only ¼ mile in width, but its depth there is more than 200 feet. Before construction of the Holtwood and Safe Harbor dams the river from south of Long Level to the mouth of Muddy Creek was a long stretch of rapids and waterfalls with rocky islands. After these dams were built the character of the river was changed by the formation of two long lakes above the dams. The northern lake has empounded the water to Wrightsville, and the southern, Tucquan Lake, (see Pl. 7 A) extends to Shenks Ferry. The upper end of a third lake produced by the building of the dam near Conowingo, Maryland, reaches the mouth of Muddy Creek.

In the early days of the white settlers great runs of shad came up the river, and eels, herring, bass, and rock fish also made their way up its waters, which contain also many indigenous fish. Formerly the shad fisheries were located near the mouth of Muddy Creek, at Cullys Falls, 1 mile south of the Holtwood dam, near Lockport, and Wrightsville. These places were used for fishing previously by the Indians, and Indian Rock near Safe Harbor was called the "Fish Pots." The building of the dams has shut off the migrations of the fish up the river.

The river flows largely on bedrock. Rocky islands are numerous. Fry and Piney Islands were crossed by the Holtwood dam. Hill Island, 2 miles north of Goldsboro, another rocky island, rises 220 feet above the river. The stream flows in deep channels on both sides of it.

The quantity of water carried by the river is small in comparison to the size of its valley, the river being in this sense an underfit stream. The explanation is doubtless to be found in the fact that at one time during the retreat of the ice of the glacial epoch the drainage from the Finger Lakes of New York went chiefly southward through Susquehanna River and the volume of water carried by the river at that time, therefore, was probably much larger than it is at present. The flow of water in the river is extremely variable. Between 1911 and 1916 the average flow below the Holtwood Dam was 20,000 second-feet, the maximum 440,000 second-feet, and the minimum 2,000 second-feet. In a dry season in summer, when the river level is often at its lowest, it was possible, before the building of the dams, to walk across the river on the exposed ledges (see Pl. 5 A & B) except for the main narrow river channel.

A. Susquehanna River near Pequa, Lancaster County.
Showing rock ledges before the building of the dam at Holtwood.

B. Dry channel along York County side of river below Cullys Falls, showing Holtwood dam in distance.

During the construction of the dam at Holtwood (see Pl. 6 A & B, 7 A) in 1905 the river was diverted into the western channel and the eastern channel was exposed to view, showing a narrow chasm a mile long with vertical walls. These long depressions or "deeps" below the general level of the river channel have been described by Mathews.[5] Six of these deeps occur between Turkey Hill and Fites Eddy, where the channel is near the left bank. They range from 2 miles to slightly less than a mile in length and attain a maximum depth of 30 feet below sea level. They are confined to the eastern edge of the rock channel and are associated with large potholes. No entirely satisfactory explanation has been proposed to account for the origin of these remarkable holes. Mathews believed that they were the work of post-Talbot erosion during a time when the river channel was either narrower or the volume considerably greater than at present. Such increase in volume might have been caused by increased drainage through the Susquehanna, but it is difficult to explain by increased volume the localization of the deeps. Daly[6] has suggested that a more probable reason for the formation of these depressions is an increased gradient of the stream on the southerly slope of a peripheral bulge of the land south of the continental ice cap. But study of the tributary drainage in the zone of the assumed peripheral upwarping of the crust shows no such trenching as must have accompanied a steepening in gradient sufficient to account for the carving of the Susquehanna deeps. Moreover, the crest of the bulge must have been at no great distance from the foot of the ice sheet, which in this region was as much as 110 miles from the stretch of Susquehanna River between Long Level and the mouth of Muddy Creek. In the case of the chasm at Holtwood, Roddy[7] states that "on its borders were hundreds of very deep and narrow potholes and on its floor roughly hemispherical ones of much larger diameter. The lower end of the canyon ended in an abrupt rock wall. All these features indicate that the chasm had been slowly lengthened by pothole after pothole being formed at the upstream end of the chasm and then, as they grew larger, merged into a deep narrow chasm. But as the old ones merged, new ones formed and thus, after thousands, but more probably millions of years, the mile-long canyon resulted. In time natural forces would have completed the work to Cullys Falls (a mile below the present dam at Holtwood), broadened out the passage, and thus drawn all the water into the eastern channel, with a lower and easier way to the sea than it had in the western one." The tail race of the power plant at Holtwood now flows in this gorge near the eastern shore.

The steep slopes along the river are generally covered with a dense growth of trees and shrubs. In these woods, notably along the north face of Hellam Hills and southeast of Long Level, rare ferns and a wide variety of wild flowers reward the visitor, especially in spring. In many places dense thickets of laurel and rhododendron add to the beauty of the slopes and ravines, and in fall the pawpaws contribute

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[5] Mathews, E. B., Submerged "deeps" in the Susquehanna River: Geol. Soc. America Bull., vol. 28, pp. 335-346, 1917.

[6] Daly, R. A., Oscillations of level in the belts peripheral to the Pleistocene ice caps: Geol. Soc. Amer. Bull., vol. 31, p. 314, 1920.

[7] Roddy, H. J., op. cit., p. 16, 1916.

A. Holtwood dam and wooded slopes of Susquehanna River, York County.

B. View looking north up river to Holtwood dam, and river gorge at McCalls Ferry in distance.

their fruit to those that visit the river valley. In recent years favorable locations along the river have been occupied by summer cottages of nearby residents. On either side of the wooded gorges of the river and lower reaches of its tributaries the country changes abruptly on the hill tops to a wide upland of tilled land and orchards.

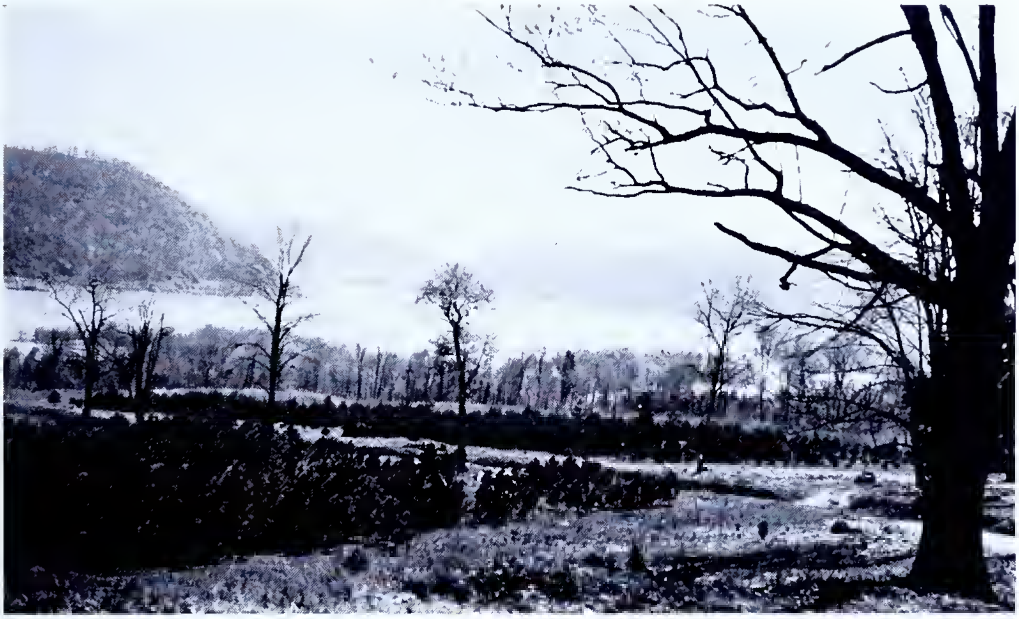
Of the larger streams that flow into the Susquehanna, Yellow Breeches Creek heads outside of the county and follows a meandering course northeastward along the northern boundary of the county. Conewago Creek heads in southwestern York County, flows north across Adams County and enters York County again 3 miles north of Abbotstown. It flows northeast across the county, and 2 miles south of Yorkhaven divides at the flood plain of the river, one stream flows north and the other south, on the west side of a low island which is the delta of the stream. The northern outlet enters the river at Yorkhaven below Conewago Falls. The Indian name, Conewago, means "at the rapids." The other outlet is at Saginaw, 3½ miles to the southeast. There is a minor outlet across the island. The water in the river above Yorkhaven is diverted to the head gates of the power plant at that place (see Pl. 8 A & B) by a low dam extending diagonally across the west channel of the river to Threemile Island near the Lancaster County side, and across the east channel to the east bank.

Codorus Creek and its three branches head in the southeastern upland of York County west of the main divide and flow north across the upland. The combined stream passes through the city of York and through the western extension of the Hellam Hills in a rocky gorge and empties into the river east of Haldeman Riffles. Muddy Creek also heads in the southeastern upland but east of the main divide. The north and south branches unite at Muddy Creek Forks and the stream flows southeast nearly to Bryansville and then turns northeast, reaching the river 6 miles north of the Maryland line. Deer Creek rises south of the Shrewsbury divide and enters Maryland, through which it flows southeastward into Susquehanna River.

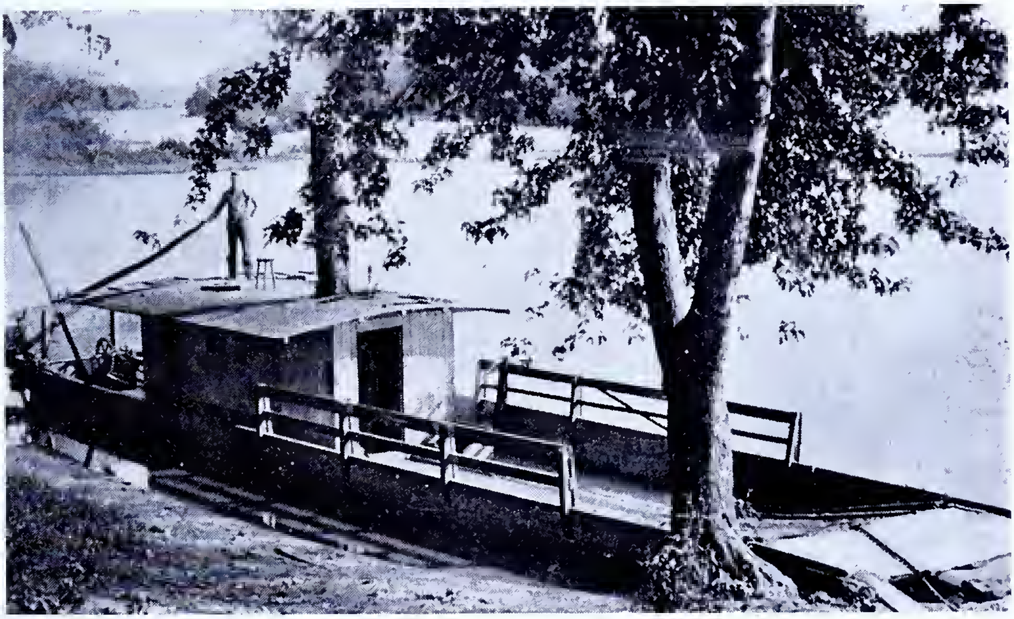
Chesapeake drainage.—The headwaters of Beetree Run and Gunpowder Falls rise on the south side of the Shrewsbury divide and drain southward into the Gunpowder Falls, a part of the Chesapeake drainage.

Highways

Two main federal highways cross at York. The east and west road, U. S. Route 30, is called the Lincoln Highway. It enters York County at Wrightsville on a toll bridge completed in 1930. It extends across the county and is part of the main highway between Philadelphia and Pittsburgh. When York was laid out in 1741 this road, west of Susquehanna River, was called Monacacy road, and the first bridge erected in the county was built on it in 1743 where the road crosses Codorus Creek at Market Street, then High Street, in York. At that time Monocacy road connected by Wrights Ferry with the Conestoga road, which lead eastward to Philadelphia.



A. View looking south, down the river, at Tucquan Lake above Holtwood dam. Duncan Island and the gorge at McCalls Ferry in distance.



B. Ferry-boat formerly used at Peach Bottom.

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The first bridge at Wrightsville was built in 1814. It was removed by ice in 1833 and the second bridge, built in its place, was destroyed by the Union Army in the Gettysburg campaign to prevent Gordon's brigade of the Southern Army from crossing the river and penetrating farther east in Pennsylvania. After that time vehicular and passenger traffic used the Pennsylvania Railroad bridge (see Pl. 2 B) over the river until the present highway bridge was built in 1930.

The north and south main highway, U. S. 111, that intersects the Lincoln Highway at York extends from Baltimore to Harrisburg. It crosses the county from Shrewsbury near the Maryland line to New Cumberland on the northern border of the county. U. S. Route 15 crosses the northern part of York County, passing through Dillsburg, and extends north to Harrisburg.

The county also has a network of hard-surfaced State highways and many county roads which are graded and improved with crushed stone. The Peach Bottom road, now State Highway 74, was laid out in 1752. It extends southeast of York across the eastern part of the county to Delta.

Railroads

Before any railroad was built in York County a canal constructed in 1832 followed the Codorus from York north to Susquehanna River and connected with the canal on the west side of the river which carried products from York to Baltimore. These canals have long fallen into disuse. In 1834, three passenger railroad coaches drawn by horses arrived at Columbia from Lancaster. This railroad was purchased in 1854 by the Pennsylvania Railroad. Connection with the Codorus Canal was made by a tow-bridge to Wrightsville.

In 1838 a railroad was built between Baltimore and York and in 1843 a branch was constructed from York to Wrightsville, where a ferry connected it with the railroad east of Columbia. In 1850 the York and Cumberland Railroad was built between York and Yorkhaven.

These roads and a branch that runs southwest to Hanover and Gettysburg were consolidated into the Northern Central Railway in 1854. The Northern Central Railway is now a part of the Pennsylvania system and the railroad across York County is their main line from Washington to Harrisburg. It enters York County from the divide at New Freedom and extends north along Codorus Creek through York and reaches the Susquehanna River at Yorkhaven. Northward it follows its west bank to Harrisburg. The Stewartstown branch of this railroad connects Stewartstown with the main line at New Freedom. The Atglen and Susquehanna branch of the Pennsylvania Railroad follows the Lancaster County side of the river from Columbia westward to a point a mile west of Shocks Mills, where it crosses the river and follows the York County side of the river to Harrisburg. This line carries freight only and is locally known as the "low-grade freight line" because it maintains a maximum grade of 5 feet to the mile between Philadelphia and Harrisburg. The Western Maryland Railroad extends from York through Spring Grove to Hanover, and has a branch up West Branch of Codorus Creek into Maryland.

A. Yorkhaven power plant and dam, of the Metropolitan Edison Co., York County.

B. View looking northwest, up river, at lake above the Yorkhaven dam. Hill Island, composed of diabase, in the distance.

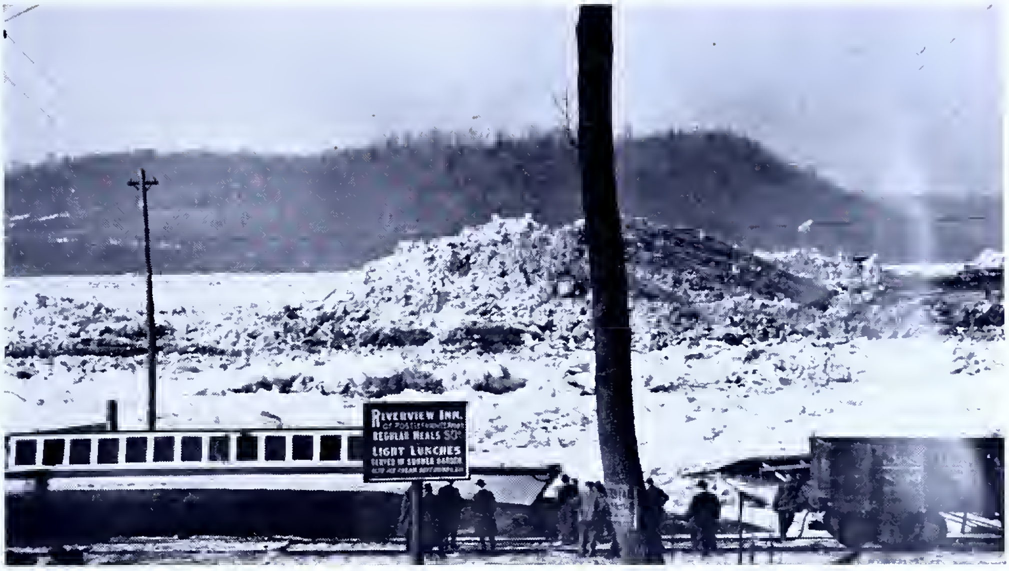
The Maryland and Pennsylvania Railroad runs between Baltimore and York. It enters the county at Delta and, from a point just north of Bryansville, follows Muddy Creek to the divide at Red Lion and northward follows Mill Creek to York. It serves the slate belt at Delta-Cardiff. The railroad, originally called the Peach Bottom Railroad, was built in 1868 as a narrow-gauge road from York to Delta. A man named Boyd, of Baltimore, promoted the road and planned to have it extend from York to Oxford, Chester County, Pa. The Rev. Samuel Dickey of Oxford was a warm advocate of the plan. Six miles of narrow-gauge railroad was built from Delta to Peach Bottom, York County. In 1875 a narrow-gauge road was built also from Peach Bottom, Lancaster County, extending eastward to Oxford. By the original plan the railroads on the two sides of the river were to be connected by a bridge at Peach Bottom, but when no bridge was forthcoming, Boyd built a narrow-gauge road from Delta into Baltimore and the 6 miles of road east of Delta and extending to the river was abandoned and the railroad from York to Baltimore soon was made broad gauge. The railroad east of the river was continued as a narrow-gauge road. A branch from Fairmount to Quarryville was called the Lancaster, Oxford and Southern; locally it was called ''The little old and slow'' (L. O. & S.). The last run on this road was made in October, 1919, after which the rails were torn up and the rolling stock and engines sold.

From early days a ferry connected York and Lancaster counties at the Peach Bottoms. In the later days a vehicular ferry boat run by a steam engine (see Pl. 7 B) was used here and at McCalls Ferry. Since the flooding of the shores of the river by the waters of the Conowingo dam, the road to old Peach Bottom settlement on the York County side is little used. A branch of the Reading Railroad running between Harrisburg and Shippensburg enters the county at Grantham and leaves it 2½ miles to the west, at which point a spur branches off southward to Dillsburg.

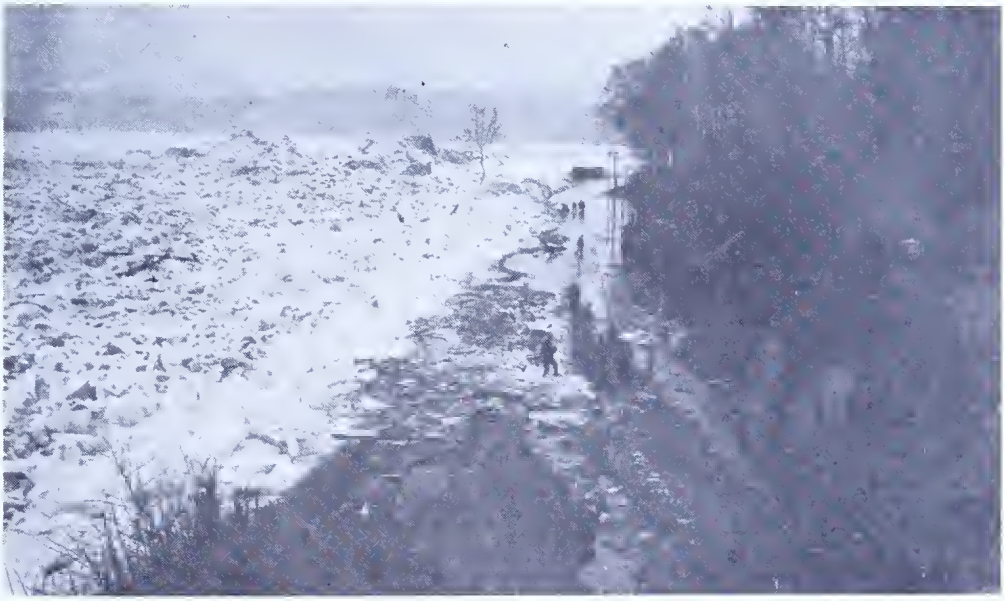
The York Railways Company owns 65 miles of trolley line, now largely served by busses in York and connecting the city with nearby towns, which include Yorkhaven, Dover, Dallastown, Wrightsville, and Hanover. Passenger bus lines which pass through York include the Greyhound-Yelloway, Edwards Transit Co., Colonial Stages, and Nevin Bus Lines. York and vicinity is served also by commercial truck lines.

Industries

Farming is the chief industry of the county. In 1929 the yearly crops were valued at $11,558,007, the dairy products at $2,994,560, and livestock at $7,996,187. The city of York is famed for its industrial establishments. Its industries are highly diversified and its ten largest industrial plants produce ice-making and refrigerating machinery, bank safes and vaults, water turbines, artificial teeth, wall paper, roofing paper, pretzels, commercial auto bodies, auto tire chains, and bakers' machinery. It is noted also for the production of twenty other commercial products and manufactures, including ⅛ of all the cigars made in the United States.



A. Ice jam at Pequa in January, 1915. View looking west to York County.



B. Pennsylvania Railroad south of Pequa flooded by the ice jam of January, 1915.

Climate

The mean temperatures for the county are 34° F. for winter, 50° for spring, 76° for summer, and 55° for fall. The maximum summer temperature rises above 95°, and the minimum winter temperature falls below zero, especially in the month of February. In spring the last killing frost occurs from April 6 to May 27, and in fall the first killing frost from September 17 to November 14, according to the season and to the altitude of the section. Sudden melting of the ice and snow in the mountains often causes the formation of ice gorges in the Susquehanna River. The ice gorges are due to an insufficiency of water to carry out the floating ice blocks, which are penned up in narrows of the river and refrozen into a solid mass by sudden drops in temperature. The resultant ice jams (see Pl. 9, A & B) have attained great size in Susquehanna River below Columbia and have caused much damage to river property, both by ice work and by flooding of the shores of the mainland and tributary streams.

The mean annual rainfall is 38½ inches, as shown by records at York. Records at Holtwood covering the period from 1915 to 1920 show a mean annual rainfall of 37 inches, with a maximum of 46 inches. Severe wind storms and tornadoes are exceptional. Thunder storms accompanied by hail are locally destructive to crops in midsummer.

Human History

William Penn received a grant of land in Pennsylvania and Delaware from the Duke of York, later King James II, in 1682. The Pennsylvania territory had been granted originally to the Plymouth Company in 1606 and later, in 1620, to the Plymouth Council of New England, but was not settled by them. Also Charles I, father of the Duke of York, had previously granted the Pennsylvania Territory to Lord Baltimore. The area included in the province of New Netherlands, which Charles II took from the Dutch in 1664, was given to his brother, the Duke of York. New Netherlands extended from Hudson River to Cape May at the entrance to Delaware Bay, but did not include any land west of the bay. The Duke of York, however, took charge of the Swedish and Dutch settlements on the west shore, and New Jersey was granted to Lord Berkeley and Sir George Carteret. William Penn in 1676 was a trustee of certain Quaker estates in New Jersey. The Quakers had not been well treated in New England and Maryland, and were desirous of founding a colony of their own. The Crown owed a debt to the estate of the late Admiral Penn, and Charles II and the Duke of York discharged the debt to his son William by granting him a charter for lands west of the Delaware and north of Maryland. Lord Baltimore's charter placed his northern boundary at the 40th parallel of latitude, which runs a little north of Philadelphia and, in present York County, 3 miles south of Wrightsville, where Fort Susquehannock was erected on the west side of the river. However, when Penn's charter was drawn up, the southern boundary was made to begin 12 miles north of New Castle, thence to curve northwestward to the 40th parallel. When it was found that this did not give Penn access to the sea, the Duke of York gave him the land on the west shore of Delaware Bay, and there followed a boundary dispute between William Penn and Lord Baltimore for the possession of land south of the 40th parallel. This dispute was not settled until 1732, when the fifth Lord Baltimore yielded all his rights to what is now Pennsyvania. Meanwhile, until the boundary dispute was settled, neither William Penn nor the Proprietary Government of Maryland could collect taxes in the border areas. The Pennsylvanians continued to survey grants in the Nottingham tract on both sides of Susquehanna River, in part in Maryland, while the Marylanders pushed north on the west bank of the river into the present York County. In 1732 a temporary line was surveyed near the present line. The Mason and Dixon line, now the present boundary, was surveyed in 1763-68, resurveyed by Graham in 1849-50, and again surveyed in 1902. The report on this survey was published in 1908 by the Maryland Geological Survey. The monuments along the boundary are set up at 1 mile intervals, and are marked M and P, and at every 5th mile is placed the crown stone bearing the coat of arms of the two proprietors. The monuments were cut in England from oolitic limestone and are 3½ to 5 feet in length. The cross section is square with each side 1 foot wide. The top is a flat pyramid. The original crown stone from near New Freedom is now in possession of the Historical Society of Maryland and a new one from the marble quarry at Cockeysville has replaced it. A new crown stone of Port Deposit granite has been placed at the foot of the bluff at the river in York County. The numbers of the stones on the York County line range from 24 at the river to 64 at the west end of the county.

Settlement in the county began in 1729, when John and James Hendricks located near Kreutz Creek. John Wright, after whom Wrightsville was named, was an early pioneer. The city of York was settled in 1729 by a party of Germans under a charter granted by William Penn. The Germans, largely immigrants from the Rhinish Palatinate, settled in the limestone valleys. Quakers, mostly English, settled the northern part of the county and also in a part adjacent to Maryland, where there were also many Scotch-Irish settlers. These pioneers came to America seeking religious liberty and the religious sects represented in the settlement of York County include Mennonites, Moravians, Dunkards, Scotch-Irish Presbyterians, and Quakers. Members of the Church of England were also among the early settlers.

The central part of what is now the city of York was laid out in 1741 by Thomas Cookson. It was located in about the center of what was then known as Springettsbury Manor, containing 64,000 acres. This manor had been granted to Springett Penn, a grandson of William Penn, in 1722. Although many of the early settlers were German, the English influence is apparent in the names of such streets in York as Queen, Duke, King, Princess, and George. The county was named from the Duke of York, and the "white rose of York" is still its symbol.

The settlers came into the county largely along Monocacy road that followed an old Indian trail along the limestone valley from Wrightsville at the Susquehanna to the Potomac River in Maryland. This road passed along what is now Market Street, the main east-west street of York, and in eastern York County has been followed by the Lincoln Highway. In 1756 the first courthouse was erected in Center Square in York at Market and George Streets. When the British occupied Philadelphia in 1777 the Continental Congress moved westward, stayed one day at Lancaster, then crossed the river, and for 9 months, from September 30, 1777, to June 27, 1778, was in session at York in the little courthouse in the square. At the close of the Revolution, the population in the present limits of York County was 17,007, with 657 colored slaves.

James Smith, a member of the Congress from York and a signer of the Declaration of Independence, lived in York and is buried in the First Presbyterian Church yard at Market and Queen Streets. Philip Livingston, another signer, is buried in Prospect Hill Cemetery. Penn Common was a direct gift of the heirs of William Penn when the city was founded. York became a borough in 1787 and was incorporated as a city in 1887.

In Pennsylvania smaller settlements are incorporated as boroughs. The use of the word borough goes far back in English history. The primary meaning is fortress, and in early English usage a borough was a small thickly populated "hundred" surrounded by a durable wall. A "hundred" was a small aggregation of people united by a common local government, and the term "hundred" was used for such settlements in Virginia. The name in some cases is still retained, as in Bermuda Hundred. A borough was a special, compact, fortified type of "hundred," and the use of this name for smaller places has persisted in Pennsylvania.

The first industries were lumber, derived from the surrounding hardwood forests, and tan bark for the leather industry. Surplus grain was used for distilling liquor. Rags and waste were used in paper making. The brick and lime industries grew during the early building of the settlements. The first foundry and forge were built in 1820, and 3 years later a blast furnace was constructed. Among the early furnaces in the county are Margaretta Furnace, built in 1823, York Furnace, in 1830, and Codorus Furnace, and Castle Fin Forge (see Pl. 10 A & B), named in honor of Robert Coleman, who was born in the village of Castle Finn, Ulster, Ireland.

Slate quarrying in the Peach Bottom district was begun in 1785 by William Decker and the slate was used in roofing Slate Hill Church east of West Bangor, which was built in 1805. Around 1845-46 Welsh immigrants entered the district, bringing professional slate quarrymen, and after that time quarrying on a larger scale began. After 1850, when facilities for quarrying were improved, the quarries were carried to greater depth, and by 1880 quarries were essentially as they are today.

The first railroad steam engine to be used in the United States was built in York by Phineas Davis, and called "The York." It was used by the Baltimore & Ohio Railroad between Baltimore and Ellicotts Mills in Maryland.

A. Castle Fin (Forge) and old highway bridge over Muddy Creek.

B. Old Codorus iron furnace near mouth of Codorus Creek. Built of Chickies quartzite.

After the Civil War tobacco growing and cigar making flourished, and the metal and the machine industries of the present day followed.

References to Indian activity that preceded white settlement in the county is given under the heading Drainage, in connection with the derivation of names from the Indian language.

DESCRIPTIVE GEOLOGY

Previous work.—The earliest geologic descriptions of York County known to the writers were made by T. G. Clemson[8] in 1834. He described the diabase and the blue, baked sandstones and "graywacke schist" on its borders, and noted the limestone conglomerates, which he compared to Potomac marble, in what are now called Triassic rocks. The schists of the county he called phyllades and "transition slates." The Second Geological Survey of Pennsylvania published the results of their study in county reports, and in 1879 J. P. Lesley, the State Geologist, published a geological map of York County by Persifor Frazer, Jr. Frazer[9] described the iron ore from the vicinity of Dillsburg and South Mountain (C-1, pp. 1-76 and C-2, pp. 205-239) and added a general description and cross sections of the rocks of the county.

Both Lesley and Frazer termed the rocks older than the limestones hydromica schist and Potsdam quartzite. The limestone was called Silurio-Cambrian, and Triassic rocks lying north of these older rocks were recognized as "New Red" sandstones. Walcott[10] reviewed the earlier work of the Pennsylvania geological surveys, described sections in the limestone south of Emigsville and the faunas from around York, and concluded that there is no rock in York County younger than Lower Cambrian except the Mesozoic "New Red" sandstone. Most of his fossil localities in the limestones are now covered by York city development. Charles Schuchert and Atreus Wanner also collected fossils near York.

Recent field work.—Field work on the South Mountain area was done by G. W. Stose[11] who mapped the Carlisle quadrangle in 1903 to 1908 and made a reconnaisance of the adjacent Cumberland Valley and the Lebanon Valley in 1910-1916. Eleanora B. Knopf and Anna I. Jonas began field work in the southeastern part of York County in 1915, and completed the work during 1919-1921. The results were published in 1929.[12]

Field work on the southeastern part of York County was started by the writers in 1920 during a reconnaisance of the valley limestones, from Hanover to Quarryville in order to establish the lower Paleozoic section of the region and to correlate the formations of the Hanover

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[8] Clemson, T. G., Observation on the geology of York County: Trans. Geol. Soc. Pa., vol. 1, pt. 2, 1834.

[9] Frazer, Persifor, Jr., Report of progress in York and Adams Counties for 1874, Pennsylvania 2d Geol. Survey C-1, 1876; and for York, Adams, and Franklin Counties for 1875, C-2, 1877.

[10] Walcott, C. D., The Cambrian rocks of Pennsylvania: U. S. Geol. Survey Bull. 134, pp. 9-19, 1896.

[11] Stose, G. W., White clay of South Mountain, Pa.: U. S. Geol. Survey. Bull. 315, pp. 322-334, 1907. Phosphorus ore at Mt. Holly Spring, Pa.: U. S. Geol. Survey Bull. 315, pp. 474-483, 1907.

[12] Knopf, E. B., and Jonas, A. I., Geology of the McCalls Ferry-Quarryville District, Pa.: U. S. Geol. Surv. Bull. 799, 1929.

Valley in Adams County with those in the valleys to the northeast. As a result, the writers published a section of the lower Paleozoic[13] rocks of southeastern Pennsylvania and also a paper on the Ordovician overlap[14] in the area.

Detailed mapping of this area was carried on during parts of the spring and fall field seasons from 1922-1937. The work was done in cooperation with the Pennsylvania Topographic and Geologic Survey, A. I. Jonas representing the State and G. W. Stose the Federal Survey.

In 1925 G. W. Stose[15] published a preliminary report on the mineral resources of Adams County. The geology of the Fairfield-Gettysburg[16] area published as a folio of the Federal Survey followed in 1929, and in 1932 a final report on Adams County[17] was published by the State Survey.

Reports on the area east of York County[18] were published by the Federal and State Surveys. The report on the Middletown quadrangle included part of York County.

A report on the Hanover-York district by the writers of this report is being published by the Federal Survey. That report gives a fuller description of the structure and the microscopic character and metamorphism of the rocks of the area than is included in this county report.

Field work on the Triassic rocks of the New Cumberland quadrangle of northwestern York County was done by M. H. Bissell in 1920 to 1922 for the State Survey. A report, including a geologic map covering these Triassic rocks, was prepared by him but was not published. The writers of the present report revised the geology of this area in the field during 1937 and 1938, have rewritten all of the description of the Triassic rocks to harmonize with reports on adjacent regions, but have incorporated data from Bissell's report.

General statement

The rocks of York County comprise pre-Cambrian crystalline rocks of both igneous and sedimentary origin overlain by lower Paleozoic sedimentary rocks. (See Pl. 1, in packet.) Triassic rocks, both sedimentary and igneous, occur in the county. Quarternary alluvium and gravel are present along most of the larger streams, but only the larger areas are mapped.

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[13] Stose, G W., and Jonas, A. I., The lower Paleozoic section of southeastern Pennsylvania: Washington Acad. Sci. Jour., vol. 12, pp. 358-366, 1922.

[14] Stose, G. W., and Jonas, A. I., Ordovician overlap in the Piedmont province of Pennsylvania and Maryland: Geol. Soc. America Bull., vol. 34, pp. 507-524, 1923.

[15] Stose, G. W., Mineral resources of Adams County, Pa.: Pennsylvania Topog. and Geol. Survey Bull. C-1, 64 pp., 1925.

[16] ————, U. S. Geol. Survey Geol. Atlas, Fairfield-Gettysburg folio (no. 225), 1929.

[17] Stose, G. W., Geology and mineral resources of Adams County, Pa.: Pennsylvania Topog. and Geol. Survey, Bull. C-1, 153 pp., 1932.

[18] Jonas, A. I., and Stose, G. W., Geology and mineral resources of the New Holland quadrangle, Pa.: Pennsylvania Geol. Survey, 4th ser. Topog. and Geol. Atlas, no. 178, 1926; Geology and mineral resources of the Lancaster quadrangle, Pa.: idem, no. 168, 1930. See also [12].

Stose, G. W., and Jonas, A. I., Geology and mineral resources of the Middletown quadrangle, Pa.: U. S. Geol. Surv. Bull. 840, 1933.

Triassic rocks cross the northwestern part of the county separating the older rocks into two belts. The Triassic sedimentary rocks overlie unconformably the Cambrian and pre-Cambrian rocks exposed southeast of them and are separated from the older rocks northwest of them by the Triassic border faults. Triassic diabase sills intrude the Triassic sediments and diabase dikes cut across them and extend southward into the older rocks.

The area southeast of the Triassic rocks lies in the Piedmont Plateau and forms two distinct belts. The northwestern belt, northwest of the Martic overthrust, contains folded pre-Cambrian volcanic rocks, Lower Cambrian arenaceous rocks, and lower Paleozoic limestones. The pre-Cambrian rocks are exposed in anticlines north of the Hanover-York Valley and are overlain unconformably by Lower Cambrian arenaceous rocks. These rocks in turn are overlain by Lower Cambrian limestones and the younger Conestoga limestone which together form the Hanover-York Valley. On the south side of the York valley the Lower Cambrian arenaceous rocks are exposed in the Strickler anticline, and in the Stoner overthrust block which largely covers the Strickler anticline. The arenaceous rocks of the Stoner block are of a somewhat different facies than those occurring north of the Hanover-York Valley. They are overlain by lower Paleozoic limestones in synclines largely adjacent to the Martic overthrust.

The southeastern belt is formed by the rocks of the Martic overthrust block, which crosses the southeastern part of York County from Long Level at Susquehanna River to the southwest corner of the county. The rocks of the Martic overthrust block are closely folded crystalline schists, in large part of probable pre-Cambrian age. They comprise metamorphosed sediments—chlorite-muscovite schists, albite schists, and thin quartzites of the Marburg schist, Wissahickon formation, and Peters Creek quartzite, and the Wakefield marble—and metabasalt flows and tuffaceous phyllites. In the southeastern corner of the county Cardiff conglomerate and Peach Bottom slate, of probable Ordovician age, overlie and are infolded with the Peters Creek quartzite.

The area northwest of the Triassic rocks contains folded pre-Cambrian volcanic rocks, Lower Cambrian arenaceous rocks, and lower Paleozoic limestones and shales. The pre-Cambrian rocks are exposed in anticlines that are the plunging end of the Catoctin Mountain-Blue Ridge anticlinorium which crosses Pennsylvania southwest of York County. Both the Lower Cambrian arenaceous rocks and the overlying limestones belong to a different facies than those southeast of the area of Triassic rocks. The limestones and shales are part of the Great Valley sequence.

PRE-CAMBRIAN ROCKS NORTH OF THE HANOVER-YORK VALLEY

The pre-Cambrian rocks of York County north of the Hanover-York Valley are all lava flows with some thin tuffaceous layers. They occur southeast and northwest of the area of Triassic rocks. Those to the southeast are exposed in the Hellam Hills near Susquehanna River and in the Pigeon Hills 15 miles to the southwest, just north of Hanover. In northwestern York County similar volcanic flows crop out in a small area that is part of a wider belt exposed to the northwest and southwest in adjoining Adams and Cumberland Counties.

The effusive pre-Cambrian rocks of York County comprise aporhyolite, metabasalt, and blue slate and sericite schist of probable tuffaceous origin. The aporhyolite and metabasalt are derived from bedded lava flows containing gas bubbles now filled by various minerals, and have flow banding and other structures common to lavas. Both types of lava occur in the Hellam Hills, only basaltic flows in the Pigeon Hills, and only rhyolitic flows in South Mountain, but basaltic flows occur also in the adjacent part of Adams County. The lavas were extruded on an older pre-Cambrian surface now hidden in York County. The effusive rocks were covered by Paleozoic sediments whose basal beds comprise Lower Cambrian conglomerate and quartzite containing fragments derived from the volcanic rocks. Pressure and heat, developed by the load of sediments and by lateral pressure during later folding, has recrystallized the lava flows so that no glass nor original minerals remain, but they still exhibit the textures peculiar to vitreous and semi-vitreous lavas, such as those of the Yellowstone National Park. The ash and tuff is altered to white or light-green sericite schist.

The volcanic rocks and overlying Paleozoic rocks have been arched up into anticlinal folds that trend southwestward. The resistant Lower Cambrian quartzites overlying the volcanic rocks form ridges that border and rise above the volcanic rocks exposed in the cores of the folds.

In the Hellam Hills aporhyolite, metabasalt, and thin beds of blue tuffaceous slate occur in two areas. The northeastern area extends for 2 miles along the axis of the Accomac anticline from Susquehanna River southwestward. It is surrounded by overlying Hellam conglomerate member of the Chickies quartzite except on the southeastern side, where quartzite is faulted out. The southern area has a maximum width of half a mile and is less than 2 miles in length along the strike. At the western end it is overlain by the Hellam conglomerate member, and on the northeastern and southern sides it is bounded by faults.

The volcanic rocks of the Pigeon Hills are for the most part green metabasalt with thin layers of blue tuffaceous slate. No aporhyolite has been found there. The volcanic rocks are exposed in two anticlines; the southeastern, or Gnatstown, contains a small area of volcanic rocks which, with the overlying basal Cambrian beds, are thrust northward onto the Lower Cambrian rocks of the northwestern, or High Rock, anticline. The volcanic rocks of this latter fold form an area 4 miles long in the direction of the strike and have a maximum width of 1¼ miles. Triassic sedimentary rocks overlap the volcanic rocks of the High Rock anticline on the north and strike S. 70° W. in a direction nearly parallel to the older structural trends. In the adjacent part of Adams County the Triassic rocks trend more nearly due south and the Triassic sediments cover these quartzose Paleozoic and pre-Cambrian rocks.

The volcanics of the South Mountain area of York County are largely aporhyolite and occur in a small area lying southwest of Stone Head and northwest of the Triassic border fault. This area is part of a larger area that extends westward into Cumberland County and southwestward into Adams County. The aporhyolite lies at the northeast end of South Mountain of southern Pennsylvania where anticlinal folds plunge northeastward and carry the aporhyolite and overlying Cambrian quartzites under the limestones of the Great Valley. These plunging folds are at the northeastern end of the mountain area that extends southwestward to the Maryland line, where a much wider belt of aporhyolite and metabasalt is exposed. The Triassic rocks now separate this belt from the volcanic rocks of the Hellam and Pigeon Hills, but the lavas of both areas are part of the same volcanic eruption, and are lithologically similar.

APORHYOLITE

Aporhyolite occurs in South Mountain in the northwestern part of the county and in the Accomac anticline and the eastern part of Mount Zion anticline of the Hellam Hills. In general, it is a fine-grained, hard, dense rock with or without phenocrysts of feldspar and quartz. The original glassy base has been altered to a finely crystalline mosaic of quartz and feldspar. In some varieties flow banding is preserved and shows on weathered surfaces of the rock. It varies in color from bluish gray to purple, red, or dark gray. The fine-grained rock may be termed felsite and that showing phenocrysts of feldspar and quartz may be called porphyry.

In the Accomac anticline are exposed two varieties of aporhyolite, a blue-gray fine-grained rock and a purple rhyolite porphyry. The purple variety is exposed only in the southwestern part of the area, and is separated by a white quartz vein from the blue-gray aporhyolite north of it, which comprises most of the aporhyolite of the anticline. A zone of brecciated aporhyolite extends across the blue aporhyolite from its western edge 1¾ miles N. 45° E. to the river. It is exposed in places on a secondary road half a mile north of Highmount, where it occurs in two areas each 50 to 75 feet wide, separated by fine-grained blue aporhyolite. The breccia is very striking in appearance because it is made up of various sized angular fragments of pink aporhyolite cemented by blue quartz and finely crushed aporhyolite. The fragments are broken and are penetrated by the blue quartz, with which there is abundant black tabular ilmenite. The breccia contains also some epidote-quartz veins.

In thin sections the pink aporhyolite shows euhedral feldspar in a fine quartz matrix and spherulites of quartz in radiating bundles. It contains also zircon, secondary sericite, and iron. Iron is present in the form of hematite and gives the pink color to the rock. The secondary quartz that cements the fragments and penetrates them in cracks is finely granulated.

The fine-grained blue aporhyolite in which the breccia occurs is similar to the pink variety in texture and also contains spherulites. The iron is present as small particles of magnetite. The pink color of the breccia may be due to the fact that the hot waters which brought in epidote, quartz, and ilmenite oxidized the iron of the aporhyolite from magnetite to hematite. Similar change in color has been reported by Stose[19] from South Mountain, where blue aporhyolite is altered to pink on the edges of quartz-epidote veins.

The pink breccia differs from a flow breccia in that the matrix is largely blue quartz and not aporhyolite, and the rock of which the breccia is composed consolidated without flowage, as is seen from the texture and the presence of spherulites. The breccia is probably a fault breccia or zone of crushing in the blue rhyolite and may have occurred in pre-Cambrian time because neither the blue quartz veins nor the ilmenite has been found to extend into the Lower Cambrian Hellam conglomerate member of the Chickies nearby. The blue quartz veins have been granulated during a later period of pressure.

The purple aporhyolite porphyry of the southern part of the Accomac anticline is best exposed in the small quarry of A. Fabringer, half a mile north of Highmount. It is a dark-purple porphyry with phenocrysts of pink feldspar and quartz.

The aporhyolite of the Mount Zion anticline is also a porphyry but is of a dark slate-gray color, with light-gray glassy feldspar and quartz phenocrysts, which in thin sections are seen to be cracked and veined with quartz. The groundmass of quartz and feldspar is fine-grained, with thin blades of sericite; particles of magnetite dust the rock. Near the south edge of the exposure there is light-blue aporhyolite which has been crushed. Green muscovite is developed on the cleavage planes.

The aporhyolite in South Mountain in York County comprises both the dense blue felsitic variety and the blue porhpyry. It exhibits flow banding, which is brought out on the weathered surfaces. To the southwest, in Cumberland County, some of the porphyry is reddish purple and the flow banding in some places bends around the phoenocrysts. Rhyolite containing spherulites and lithophysae have not been found in York County, although they occur farther to the southwest in South Mountain. Because of poor exposures and of folding, successive flows cannot be distinguished and no estimate of their thickness can be made.

The rhyolite belt of northwestern York County extends southwest into Adams County and a full description of it is given in the report on that county.[20] Some of the rhyolite in Adams County and adjoining Franklin County is very attractive as an ornamental stone and when polished it exhibits a great variety of colors and banding. Some of these polished specimens were illustrated in natural colors and in black and white in an early edition[21] of the Adams County report. In the Hellam Hills the rhyolite was quarried and apparently can furnish a pleasing ornamental stone of purplish-red color with white phenocrysts.

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[19] Stose, G. W., op. cit. (Adams County), pp. 23, 51, 1925; op. cit. (Fairfield-Gettysburg folio), p. 12, 1929.

[20] Stose, G. W., op. cit. (Adams County), pp. 31-38, 1932.

[21] Stose, G. W., op. cit. (Adams County), Pls. V-IX, 1925.

Two analyses of aporhyolite from Franklin County are as follows:

Analyses of aporhyolite from South Mountain, Pa.

	1	2
SiO_2	76.34	73.85
Al_2O_3	11.60	13.15
Fe_2O_3	2.41	3.27
FeO	.30	.36
MgO	.06	.32
CaO	.55	.82
Na_2O	5.50	2.29
K_2O	2.75	5.42
H_2O+	0.10	1.71
H_2	.39	
TiO_2	.26	....
CO_2	Trace	....
P_2O_5	Trace	.06
MnO	Trace	.09
BaO	.09	....
	100.35	100.34

1. Aporhyolite, Monterey, Franklin County, Pa. H. N. Stokes, analyst, U. S. Geol. Survey Bull. 150, p. 348, 1898.
2. Quartz porphyry, same locality. L. G. Eakins, analyst. U. S. Geol. Survey Bull. 148, p. 81, 1897.

VOLCANIC SLATE

The western part of the southern area of pre-Cambrian rocks of the Hellam Hills contains blue slate and spotted slate associated with epidotic greenstone schist (metabasalt). The blue rock is a dark purplish, sparkling sericitic slate, some of which contains flattened amygdules. In places it is banded with green chlorite. Sericite and hematite make up the bulk of the rock, and hematite occurs in dust-like particles that give it a bluish color. It seems probable that the original material was a volcanic tuff of rhyolitic composition. Similar blue slate occurs in places in the Pigeon Hills but has not been mapped separately from the metabasalt. Slate with similar constituents and association is widespread in Carroll and Frederick Counties, Md., east of Frederick Valley. Analyses show that the potash content is from 4.16 to 6.02 percent and the silica, lime, and magnesia content is low. This chemical composition relates it to the rhyolite rather than to the metabasalt.

In the South Mountain area the tuffaceous slate layers are less metamorphosed than in the area southeast of the Triassic rocks. They are sericitic, white to gray and pale green, and in part contain feldspar and quartz grains. A purple-red slate is associated with the rhyolite porphyry of that color. The tuffaceous slate is generally accompanied by veins of milky-white quartz, which, in Adams and Cumberland Counties, has been collected from the fields and soil and crushed for silica or "flint."[22] Similar vein quartz occurs in York County and the adjacent part of Cumberland County, but is not in sufficient quantity to be used for silica.

METABASALT

In the Hellam Hills metabasalt is exposed in the pre-Cambrian cores of both the Accomac and Mount Zion anticlines. In the northern anticline it occurs in a small area just north of Highmount and in a

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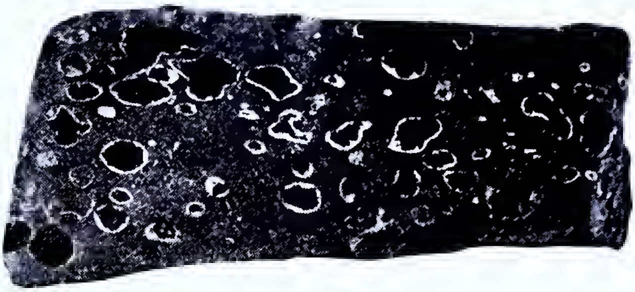
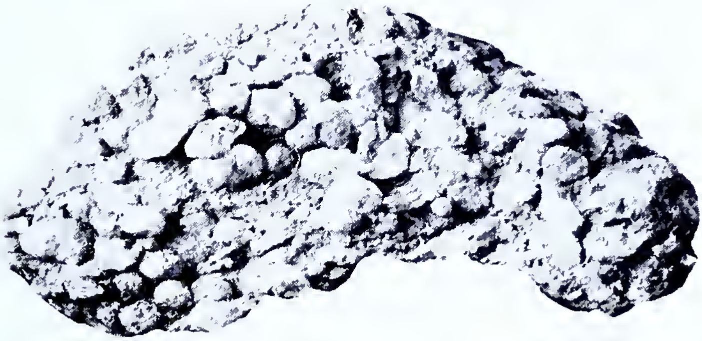
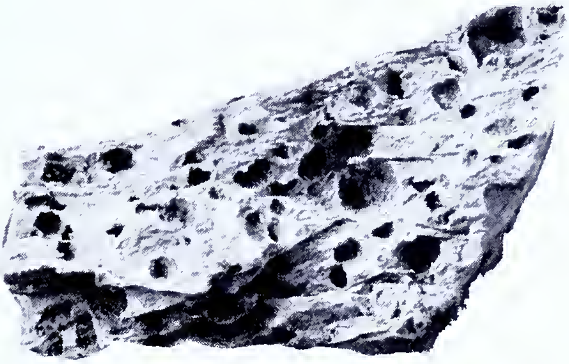
[22] Stose, G. W., op. cit. (Adams County), pp. 129-130, 1932.



A. Amygdaloidal basalt, South Mountain, Adams County.
Amygdules filled with dark chlorite and rim of white quartz.



B. Amygdules in metabasalt, weathered in relief on the surface. South Mountain.



C. Metabasalt in which the amygdular filling has been dissolved by weathering process, giving rise to a "worm eaten" appearance. South Mountain.

larger area extending for a mile along the valley of the small stream leading to the Susquehanna River at Accomac. Many good exposures are found in the gorge of this stream all the way to its mouth. Metabasalt, not so well exposed, also occurs in two places in the southern pre-Cambrian area 1½ miles northwest of Hellam. The metabasalt, or "greenstone" as it is commonly called, is a grayish-green to bluish-gray hornblende schist, blotched with green epidote, which forms knots on the weathered surface. Some massive layers are spotted with light-green or white amygdules composed of quartz, calcite, or epidote with chlorite lining. Where the amygdular filling has been dissolved by weathering processes, the rock is pitted or porous and has a "worm-eaten" appearance. (See Pl. 11, C.) In some cases the amygdules weather out as knots on the surface of the rock. (See Pl. 11, B.) The constituents of the metabasalt are epidote, hornblende, chlorite, quartz, feldspar, and magnetite. All are secondary minerals—that is, they crystallized after the original lava was poured out and solidified. Flow banding is still visible in the more massive varieties. The fine-grained parts of the flow have been altered to a schist in which the amygdules are drawn out and are now represented by flattened blebs. The rock has veins of secondary epidote and some asbestos, which is exposed just south of Accomac.

Metabasalt makes up the largest part of the pre-Cambrian volcanic rocks of the Pigeon Hills and its area is nearly 5 miles long and over a mile wide in its broadest part. The rock is similar in character to that of the Hellam Hills.

In thin-section the massive "greenstone" is made up of a groundmass of albite, epidote, quartz, and magnetite, with phenocrysts of feldspar and the green hornblende, uralite, some of which shows a core of original augite. The amygdules are filled with secondary minerals—hornblende, epidote, calcite, quartz, and albite. (See Pl. 11.) The albite feldspar of the groundmass is corroded by secondary hornblende and chlorite and is itself secondary to more calcic feldspar whose lime went to form epidote.

The original composition of the rock may be inferred from the composition of the secondary minerals that now compose it. It is thought that the original rock was probably a cryptocrystalline lava having the composition of a basalt. No analyses of the basic volcanic rock of York County are available, but the following analysis represents rock from the pre-Cambrian area of South Mountain, Adams County, Pa., which it is believed was continuous with the basement of the Hellam Hills in pre-Cambrian time.

Analysis of metabasalt from Bechtel copper shaft in Adams Co., South Mountain[23]

SiO_2	41.280	MgO	7.486
Al_2O_3	18.480	Na_2O	3.523
Fe_2O_3	9.440	K_2O	2.208
FeO	8.200	Ignition	2.740
CaO	7.040		
			100.397

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[23] Henderson, C. H., The copper deposits of the South Mountain, Pa.: Am. Inst. Min. Eng. Trans., vol. 12, p. 82, 1884.

Some of the metabasalt in Adams County makes an attractive ornamental stone when polished, as illustrated in colors in the report on the Mineral Resources[24] of the County. Some of the amygdaloid in the Pigeon Hills, if polished also might be used for ornamental purposes. (See Pl. 11.) The metabasalt in Adams and Cumberland Counties contains native copper,[25] but no copper has been found in these rocks in York County.

AGE OF THE VOLCANIC ROCKS

The volcanic rocks of York County are pre-Cambrian, because they are overlain unconformably by Lower Cambrian sedimentary rocks. No intrusive nor structural relations between the aporhyolite and the metabasalt that would show which is the older have been observed in York County. In the Catoctin Mountain-South Mountain uplift the rhyolite flows are considered older that the basaltic lavas.[26]

The floor upon which the volcanic rocks were extruded is not exposed in Pennsylvania. In southern Maryland and Virginia the lava flows rest on an older injection complex that was folded and metamorphosed before the lavas were poured out. The lava flows were somewhat folded, but not greatly metamorphosed, in pre-Cambrian time, and were in part eroded before Cambrian[27] time. The lavas are therefore of later pre-Cambrian age than the injection complex. They were folded and metamorphosed in Paleozoic time along with the rocks which overlie them, and in the belt southeast of the Triassic rocks the pre-Cambrian volcanic rocks, like the overlying Cambrian formations of that area, show greater metamorphism than the volcanic rocks and Cambrian rocks of South Mountain.

PALEOZOIC ROCKS

GENERAL CHARACTER

The Paleozoic rocks in this county and adjacent areas comprise a series of quartzites with interbedded phyllites and slates and an overlying series of limestone and dolomites with some shale.

The Paleozoic rocks of York County lie in two areas that are separated by the Triassic rocks. In the southeastern area they occur on the flanks of the Hellam and Pigeon Hills, in the Hanover-York Valley, and in the low hills south of this valley. In the area northwest of the Triassic rocks they form the flanks and plunging ends of anticlines of South Mountain and the Cumberland Valley east and north of the mountain. The rocks are of different facies in the two areas (see fig. 3) and will be described separately. The formations described are listed in the following chart.

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[24] Stose, G. W., op. cit. (Adams County), Plates V, 1925.

[25] Stose, G. W., Copper deposits of South Mountain in southern Pennsylvania: U. S. Geol. Surv. Bull. 430, pp. 122-131, 1910.

[26] Keith, Arthur, Geology of the Catoctin belt: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, pp. 309-311, 1894. Bascom, Florence, The ancient volcanic rocks of South Mountain, Pa.: U. S. Geol. Survey Bull. 136, p. 30, 1896. Stose, G. W., op. cit. (Adams County), p. 30, 1932: op. cit. (Fairfield-Gettysburg folio), p. 4, 1929.

[27] Jonas, A. I., and Stose, G. W., Age relations of the pre-Cambrian rocks in the Catoctin Mountain—Blue Ridge and Mount Rogers anticlinoria in Virginia, Am. Jour. Sci., vol. 237, pp. 575-592, 1939,

Chart of Paleozoic formations for York County and vicinity

	South Mountain and Cumberland Valley		Pigeon and Hellam Hills Hanover-York Valley		Upland south of Hanover-York Valley	
		Thickness feet		Thickness feet		Thickness feet
Ordovician	Martinsburg shale	500±	Conestoga limestone (Ordovician?)	500+	Conestoga limestone (Ordovician?)	500±
	Leesport limestone	80±				
	Beekmantown limestone and Stonehenge member	2,000±				
Upper Camb.	Conococheague limestone	1,000±				
Mid. Camb.	Elbrook limestone	1,600±				
Lower Cambrian	Waynesboro formation	750±				
	Tomstown dolomite	1,000±	Ledger dolomite Kinzers formation Vintage dolomite	1,000± 200± 800±	Kinzers formation Vintage dolomite	100-0 200-0
	Antietam quartzite	500±	Antietam quartzite	100-200±	Antietam quartzite	100±
	Montalto quartzite	1,000±	Harpers phyllite	800±	Harpers phyllite	500±
	Weverton quartzite Loudoun formation	500± 300±	Chickies slate and Hellam conglomerate member	550— 1,000±	Chickies slate and Hellam conglomerate member	350±
Pre-Cambrian	Aporhyolite Rhyolite tuff Metabasalt		Aporhyolite Volcanic slate Metabasalt		Not exposed	

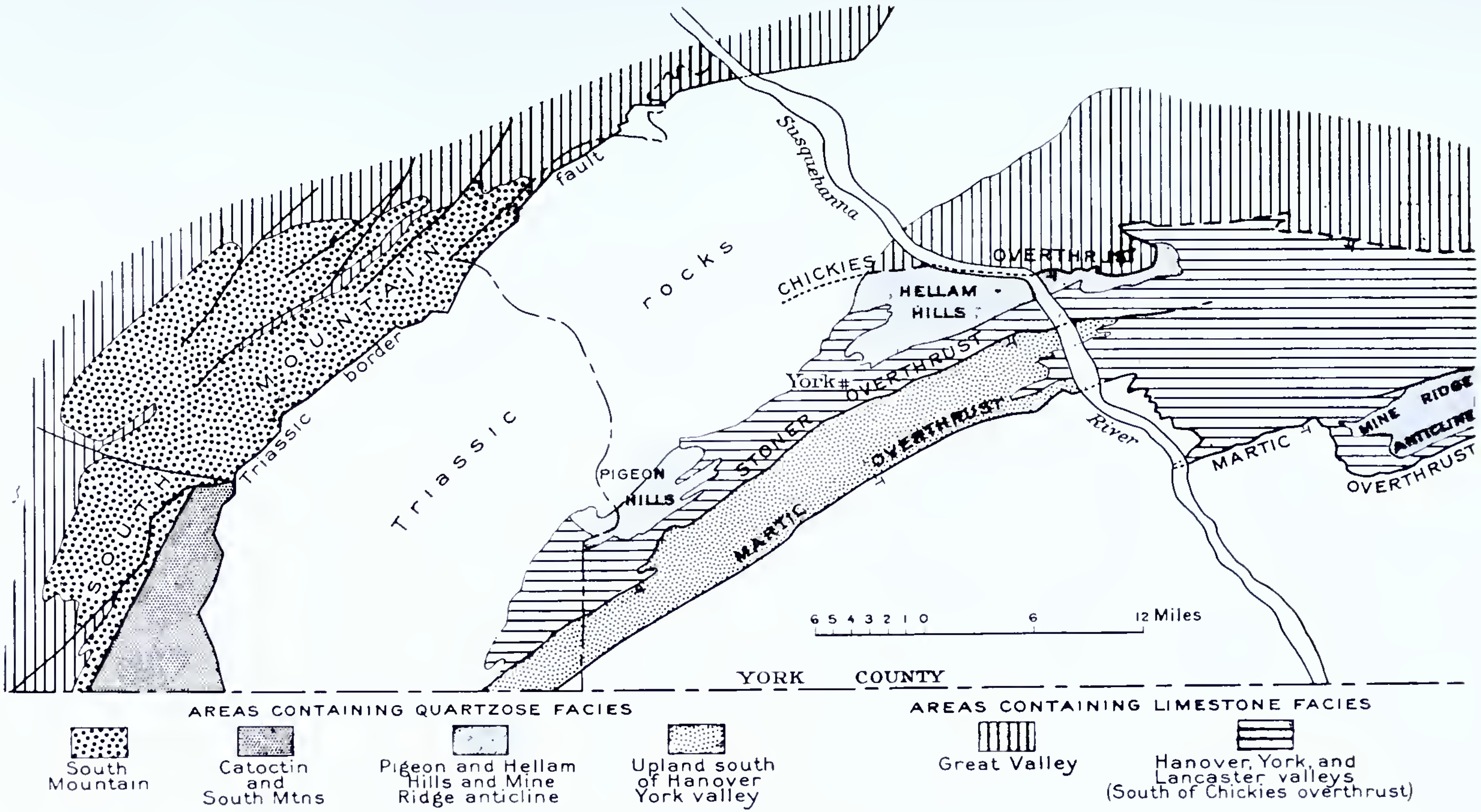


Figure 3. Map of south-central Pennsylvania, showing areas of different facies of Paleozoic sedimentary rocks. See also preceding chart.

PALEOZOIC ROCKS SOUTH OF THE TRIASSIC BASIN

Cambrian system

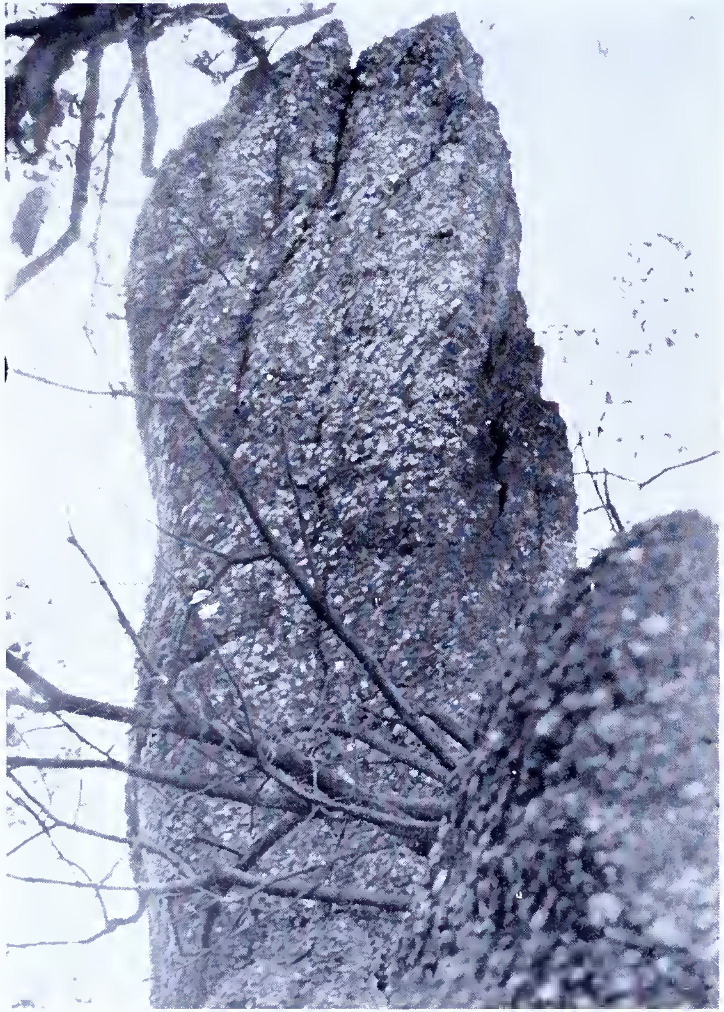
General description.—The Cambrian rocks of York County in the area south of the Triassic rocks, given in ascending order, are the Chickies quartzite with the basal Hellam conglomerate member, Harpers phyllite, Antietam quartzite, Vintage dolomite, Kinzers formation, and Ledger dolomite, all of Lower Cambrian age. The Chickies south of the Hanover-York Valley is largely a shale with subordinate quartzite beds and is separately described as Chickies slate. (See fig. 3 and accompanying chart.)

CHICKIES QUARTZITE, NORTH OF THE HANOVER-YORK VALLEY

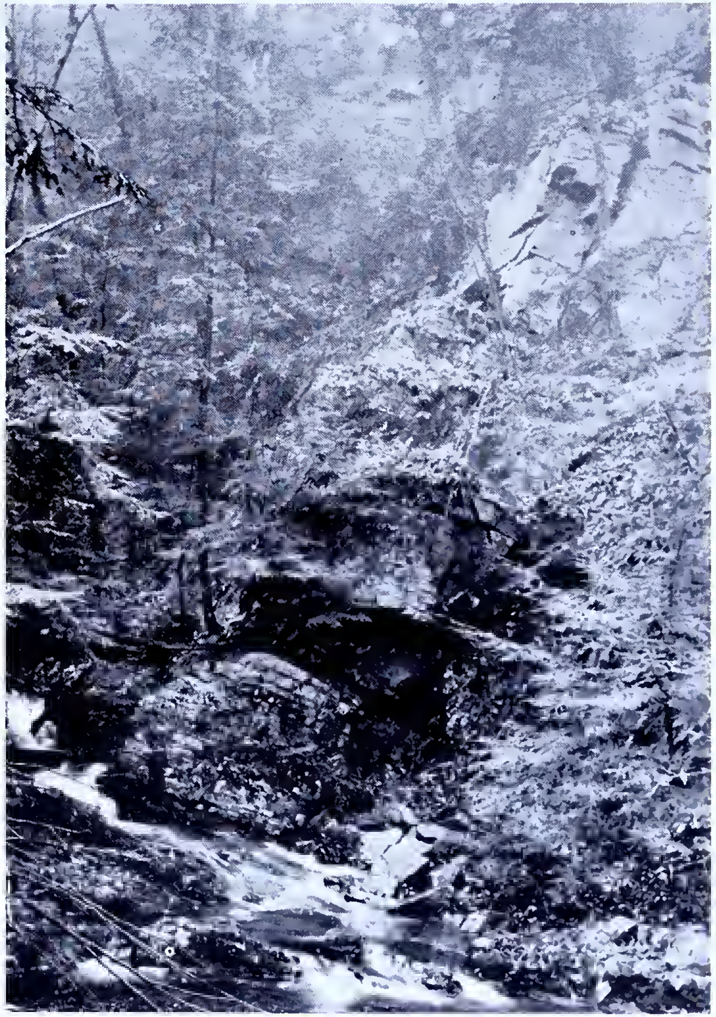
Distribution.—The Chickies quartzite forms the higher parts of the Hellam Hills northeast of York and of the Pigeon Hills north of Hanover. It was the first formation to be deposited in the Lower Cambrian sea of this area. The Chickies quartzite with its basal Hellam conglomerate member forms the Hellam Hills which extend from Susquehanna River to 2 miles southwest of Mount Zion. East of Accomac the quartzite forms a ridge with its crest in Roundtop. This ridge is the western extension of Chickies Ridge east of the river, in Lancaster County, where the Chickies quartzite forms the noted cliff called Chickies Rock. This area extends to Highmount where it is cut off by thrust faulting. The quartzite occurs also in a wide area east of Codorus Creek from the river south to Dee Run. The quartzite in this area is exposed in cliffs, in places 150 feet high, along the river from a point east of Dugan Run for 3½ miles westward. It forms Wildcat Falls and Schulls Rock east of the low-grade bridge of the Pennsylvania Railroad, two of the most scenic spots in the county. The quartzite forms a small area along Codorus Creek half a mile west of Glades and two other small areas northwest of Starview.

The Hellam conglomerate member of the Chickies lies at the base of the Lower Cambrian section and unconformably overlies the pre-Cambrian rocks in the Accomac and Mount Zion anticlines. The coarser beds of this conglomerate make prominent hills northwest of the aporhyolite of the Accomac anticline and also just north of Highmount. The highest point of this ridge, 900 feet in altitude, is at Chimney Rock where the conglomerate has weathered into pinnacles (see pl. 12 A) that stand 30 feet above the crest of the ridge. Another prominent ridge underlain by the coarse conglomerate lies east of Pleasureville and is 4 miles long. The finer-grained beds of the Hellam conglomerate member form the lower slopes of these hills.

The Chickies quartzite with its basal Hellam conglomerate member surrounds the areas of pre-Cambrian metabasalt of the Pigeon Hills except where Triassic beds overlap onto the northern edge of the metabasalt. It is folded into two anticlines which extend for about 7 miles along the strike. The southern anticline makes the southern part of the Pigeon Hills. The quartzites in the northern anticline make High Rock and other high peaks, including the highest point in the county south of the Triassic rocks, which has an altitude of 1,240 feet. These two anticlines of Chickies quartzite plunge northeastward



A. Chimney Rock. A pinnacle of Hellam conglomerate, 30 feet high, on ridge 1½ miles south of Highmount.



B. Chickies quartzite cliffs in ravine of Trout Run.

and the quartzite passes under the succeeding Harpers phyllite. At the southwest, in adjoining parts of Adams County, the Chickies is greatly narrowed and broken by faults.

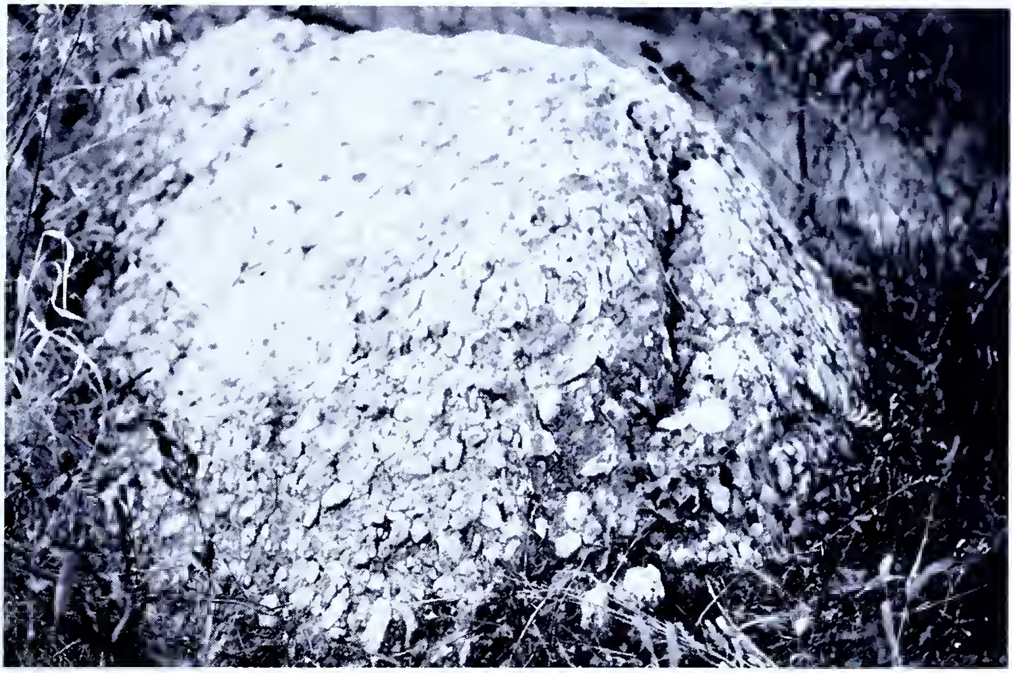
The Hellam conglomerate member in the Pigeon Hills has been mapped in two divisions. Hard conglomeratic beds predominate and make all the higher peaks and ridges, on the inner slopes of which are lower softer beds. White quartzite of the Chickies quartzite makes the outer slopes of these ridges.

Character and thickness.—The Chickies quartzite at the type locality, Chickies Rock on Susquehanna River, Lancaster County, is a massive, well-bedded, white, vitreous quartzite (see Pl. 26) many beds of which are marked by small round tubes perpendicular to the bedding, which are worm borings called *Scolithus.* The upper beds are coarser grained and feldspathic, and are interbedded with black slate layers. The Chickies quartzite in York County is similar to that at the type locality across the river. (See Pl. 12 B.) The Hellam conglomerate member at the base of these quartzites is made up of quartzose conglomerate, feldspathic quartzite, and interbedded dark slate. In the Hellam Hills the Hellam member contains thick beds of coarse conglomerate, some layers of which are made up of rounded cobble and are interbedded with finer quartzose conglomerate. (See Pl. 13, B.) Four divisions of the Hellam conglomerate member have been mapped in the Hellam Hills, and in the Pigeon Hills, where the coarse cobble conglomerate is not developed, only two divisions are mapped. The coarse cobble beds in the Hellam Hills are 5 feet thick and are composed of well-rounded cobble 3 to 6 inches in diameter in a finer quartz-sericite matrix that firmly cements the pebbles. (See Plates 13 and 14 A.) The cobbles are for the most part of milky white quartz with some red and black jasper and quartzites containing minute black hornblende needles. These beds are well exposed along the road west of Highmount (See Pl. 13, A) and extend along the ridge top to Chimney Rock (See Pl. 12, A), on the ridge forming the northwest limb of the Accomac anticline, and along the crest of the ridge east of Mt. Zion.

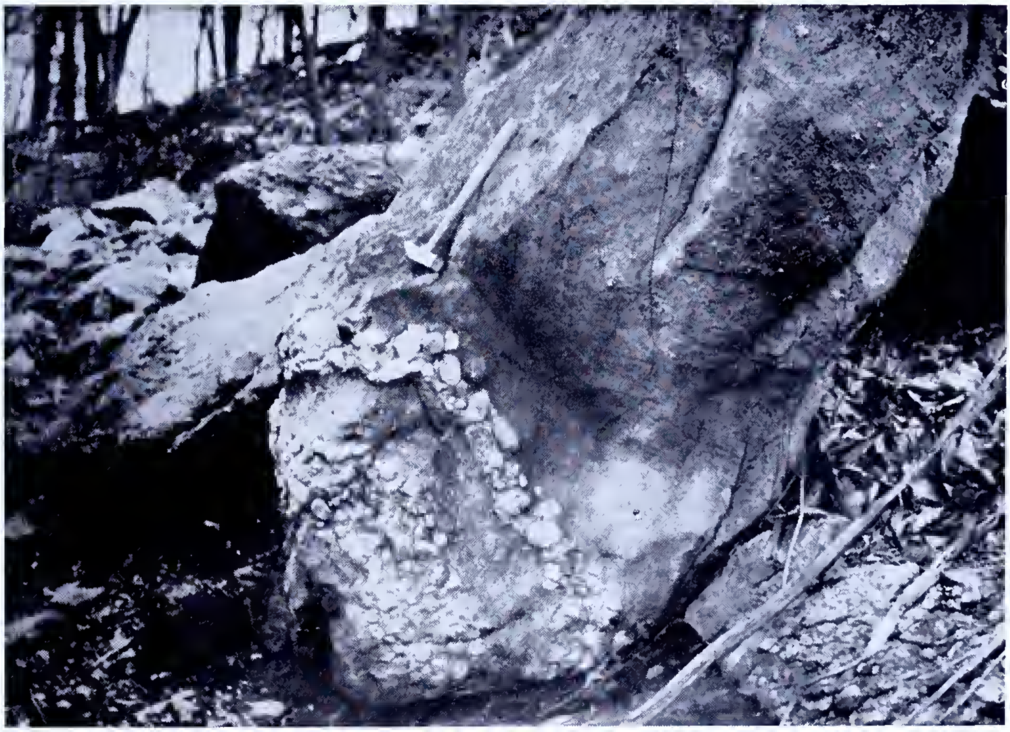
The estimated average thickness of the formation in the Hellam Hills is 550 feet, but the maximum thickness of a composite section is probably 900-1000 feet. The following sections give detailed measurements of the exposed parts of the formation:

Composite section of upper part of Chickies quartzite in vicinity of Chickies Rock

	Feet
Grayish-green phyllite and slate (Harpers)	
Thin-bedded quartzite and interbedded thin layers of dark slate..	20±
Thin-bedded white quartzite and coarse granular blue quartzite with coarse grains and small pebbles of blue and dark glassy quartz and feldspar	20±
White thin-bedded quartzite with interbedded thin layers of dark slate	40±
Slate and thin beds of quartzite banded with slate	50±
Thin- and thick-bedded white sericitic quartzite with *Scolithus* tubes, weathering to crumbly sandrock and white sericitic clay	15±
Thick-bedded vitreous white quartzite	20±



A. Hellam conglomerate member. Coarse pebble bed, near Highmount.



B. Hellam conglomerate member. Cobble bed interbedded with finer quartzose conglomerate, near Highmount.

Thin-bedded white vitreous quartzite, in beds mostly less than 5 feet thick, contaning numerous *Scolithus* tubes	100±
Very massive vitreous white quartzite, beds 20 feet thick	70±
(Base of Chickies formation not exposed)	
	355±

The section is confused by faulting and repetition of beds, as shown by sketch sections in the Middletown report.[28]

Composite section of Hellam conglomerate member on Mt. Zion Hill

	Feet
Chickies quartzite.	
Hard vitreous scolithus-bearing quartzite.	
Hellam conglomerate member	
Black and white banded slate and thin quartzite beds	200±
Hard granular feldspathic to vitreous white quartzite, current-bedded in part	20±
Argillaceous and ferruginous-banded arkosic pebbly quartzite	100±
Pebbly arkosic quartzite with scattered pebbles; at top a hard pebbly bed 10 feet thick of round white quartz pebbles, 1 inch in diameter; near base a 5-foot hard bed of coarse rounded quartz cobbles, 3 inches to 6 inches in diameter.	35±
Thick granular purple-banded arkosic quartzite with scattered pebbles	60±
Conglomerate of unassorted quartz pebbles scattered through greenish sericitic arkosic matrix	80±
Black slate	10
	505±
Pre-Cambrian	
Greenstone (metabasalt) and spotted green and blue volcanic slate.	

In the Pigeon Hills the formation is so broken up by faulting that no complete section could be measured. The sequence of beds is best shown at the sharp ravine on the south side of the mountain, 2 miles north of New Baltimore, where the water supply for Hanover is obtained from several springs. The following sequence of beds with approximate thicknesses represents the Chickies quartzite in the Pigeon Hills:

Composite section of Chickies quartzite including Hellam conglomerate member, with estimated thicknesses, in the Pigeon Hills

	Feet
Chickies quartzite.	
White vitreous quartzite, *Scolithus*-bearing	200±
Hellam conglomerate member	
Massive-bedded conglomerate, some beds 20 feet thick; makes high ridges and peaks	300±
Thin-bedded crumbly conglomerate	
Coarse conglomerate containing fragments of dark slate	
Dark slate	20±
	520±
Pre-Cambrian rocks	
Spotted volcanic slate	
Greenstone (amygdaloidal metabasalt)	

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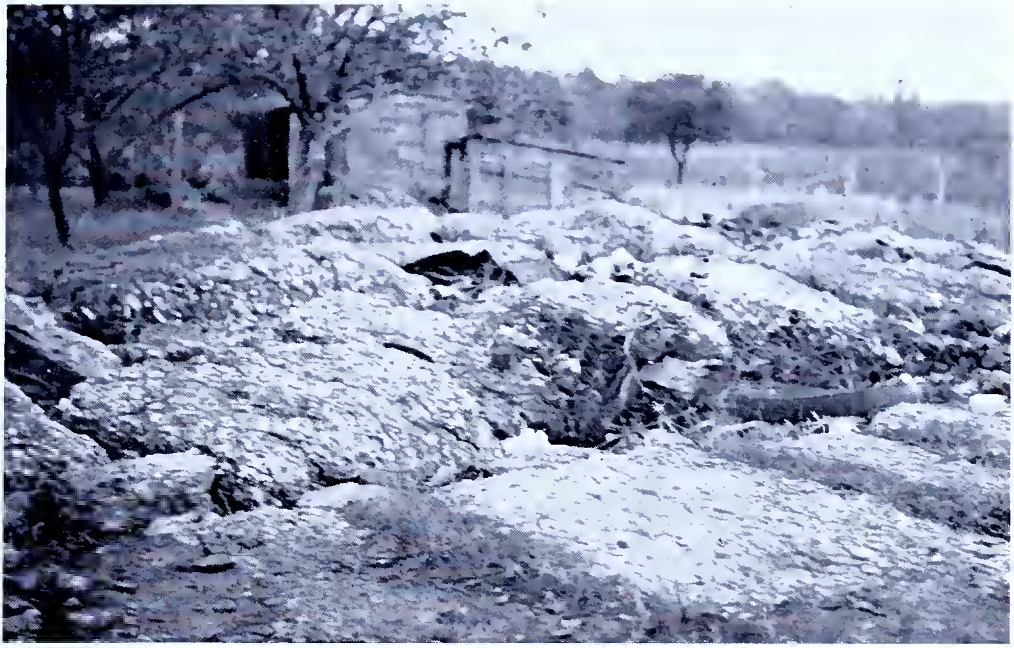
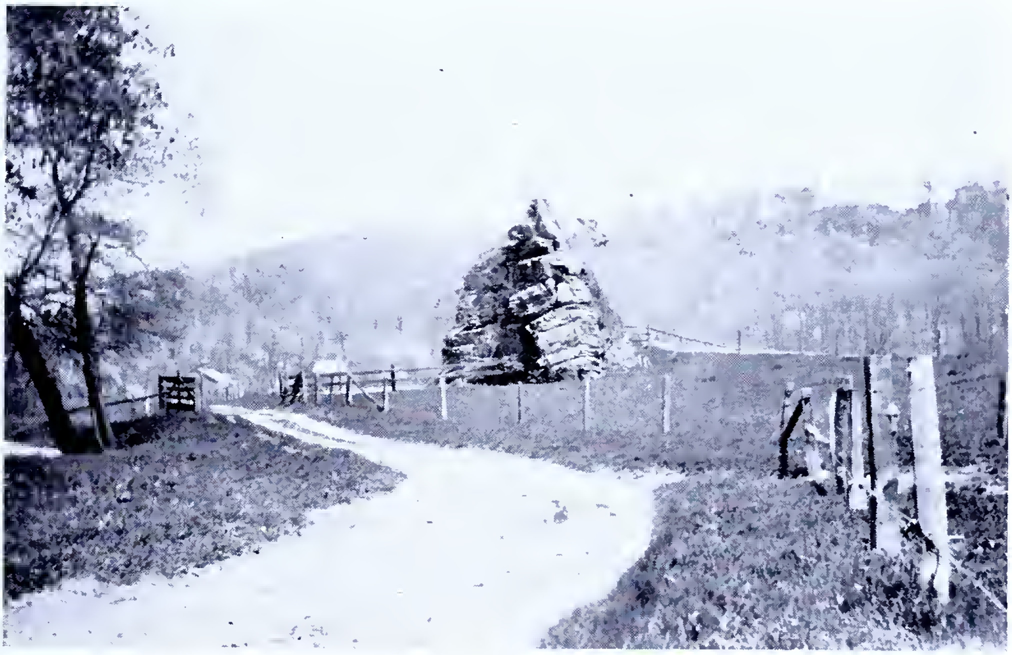
[28] Stose, G. W., and Jonas, A. I., op. cit. (Middletown quadrangle), Bull. 840, figs. 2 and 3, p. 13, 1933.



A. Nearly horizontal cobble bed in Hellam conglomerate member on top of ridge northeast of Mt. Zion.



B. Quartzite beds in the Chickies slate at crest of an anticline.
An erosion remnant in the flood plain of Codorus Creek, 1 mile north of Brillhart.

Age and correlation.—The Chickies quartzite unconformably overlies metabasalt and aporhyolite of pre-Cambrian age, and contains pebbles of blue and white quartz and slate derived from those rocks. The Chickies quartzite contains no fossils except *Scolithus* worm tubes, but it is conformably overlain by rocks that contain Lower Cambrian fossils, and it is therefore classed as Lower Cambrian. The Chickies quartzite was named in 1878 by Lesley and Frazer from outcrops of quartzite at Chickies Rock above Columbia on the Susquehanna River.

The Hellam conglomerate, the basal member of the formation, was named from the Hellam Hills in the Middletown quadrangle, where it is best developed.

CHICKIES SLATE, SOUTH OF THE HANOVER-YORK VALLEY

Distribution.—The Chickies slate is exposed along the axis of the Mount Pisgah anticline and makes a series of prominent hills about a mile wide that extends from Susquehanna River southwestward to York New Salem. A small area of Chickies slate is exposed along the same anticlinal axis south of Lehman. Chickies slate occurs also in the Holtz anticline, 2½ miles southeast of the Pisgah anticline, and extends from a point 2 miles east of Holtz southwestward to a point southwest of Spry. It is exposed also in the Kraft Mill anticline, to the southwest of the Holtz anticline but not along the same axis, in an area 12 miles long.

Character.—The Chickies slate is a black shiny slate with numerous thin plates of gray to rusty quartzite and some thicker zones of quartzite composed of beds 2 to 3 inches thick. Several zones of quartzite beds have been observed, but because of poor exposures and repetition by folding they cannot be completely traced. They have been mapped only where they make conspicuous outcrops or where quartzite debris covers the tops of ridges. They are exposed in the gorges of Kreutz Creek south of Leipharts Mill, of Mill Creek south of Plank Road, in the valley south of Violet Hill, and along the east and west Branch of Codorus Creek 1 mile north of Brillhart. (See Pl. 14 B.) In several of these areas the quartzites show anticlinal structure.

A complete section of the formation can only be approximated because of close folding, faulting, and poor exposures. The following composite section is made up from scattered partial sections and is a revision of the section previously published.[29]

Generalized composite section of Chickies slate in Mount Pisgah anticline

	Feet
Harpers phyllite:	
Green muscovite-quartz schist	
Chickies slate:	
Thin-bedded quartzite and black slate	25±
Black slate and thin platy green phyllite inclosing a 5-foot bed of hard white coarse granular quartzite	65±
Thin-bedded greenish quartzite (2-foot beds) with black slate partings and interbedded black slate	20±
Black slate, some beds banded with yellow earthy sandy layers and green phyllite, and some thin platy quartzites	50±

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[29] Stose, G. W., and Jonas, A. I., op. cit. (Middletown quadrangle), p. 18, 1933.

Thick-bedded quartzite, some beds 12 feet thick, with thinner bedded quartzite at top and bottom	60±
Black slate with few thin quartzite beds	100±
Hellam conglomerate member:	
Thick beds of conglomerate containing pebbles 1½ inches in size, with interbedded sericitic quartzite and thin black slate	30±
Base not exposed.	350±

The Hellam conglomerate member of the Chickies slate is exposed at the surface in the center of the Mount Pisgah anticline northeast of the Kreutz Creek gorge, where it forms a series of ledges along the narrow ridge which rises to 840 feet at Mount Pisgah. The best exposure is on the east side of Kreutz Creek just west of Yorkana, where the conglomerate is 30 feet thick. It crops out on the ridge to the northeast in two parallel belts, probably representing the crests of anticlinal folds, and each belt has two ledges of conglomerate, each 20 to 40 feet wide, apparently marking the two limbs of the folds. Southwest of Kreutz Creek the conglomerate member passes under the slate where the anticline plunges southwestward and does not appear at the surface to the westward. The rock is a cream-color to green schistose quartz conglomerate with blue and milky quartz grains and pebbles up to one-half inch long. It contains jasper-like siliceous hematite that colors the rock pink to red on weathering. The partings in the conglomerate are coated with green muscovite. The conglomerate layers are interbedded with sericitic quartzite and thin black slate.

Only the upper part of the Chickies slate is exposed in the Kraft Mill anticline. The harder quartzite beds, which form ridges, are fine- to medium-grained green quartzite with muscovite partings, and have thin bands of interbedded black slate. Certain beds of the quartzite are full of magnetite crystals, some facets of which are iridescent. In places north of Strickhousers the magnetite is so abundant that it has been prospected for iron. The quartzite beds are repeated by folding. The Chickies slate in the Holtz anticline is similar to that in the Kraft Mill area. The only outcrops are found in the valley of Mill Creek but large blocks of quartzite strew the surface of the adjoining ridges.

HARPERS PHYLLITE

Distribution.—The Chickies quartzite is succeeded by an argillaceous rock which is called Harpers phyllite. This rock in its type locality in the eastern part of the Appalachian Valley at Harpers Ferry, W. Va., was at first called a shale. It is a slate in the Harpers Ferry area, and in this region it is a phyllite. It forms the southeastern slope of the Hellam Hills where it is overlain by Antietam quartzite on the flank of the anticline. It overlies Chickies quartzite of the Trout Run area and is well exposed in the gorge of Codorus Creek for 3 miles southwest of its mouth. It overlies the Chickies quartzite also along the southeast slope of the Pigeon Hills. At the northeastern-plunging end of the High Rock anticline, at John Mummert School, its outcrop expands to ½ mile in width. On the south side of the Gnatstown anticline its outoutcrop is irregular, due to faulting. It passes under the succeeding Antietam quartzite, as is well shown on the plunging end of the fold at Roth Church. It is well exposed at the plunging end of the Gnatstown anticline, and in the centers of the minor anticlines farther south. It also forms the core of the Pottery Hill anticline southwest of West York.

South of the Hanover-York Valley it forms a belt about 4 miles wide that extends across the county. In this belt of Harpers there are anticlinal areas of the Chickies slate, already described, and infolds of the overlying Antietam quartzite, Vintage dolomite, and Conestoga limestone in synclines. Southwest of York New Salem the Harpers phyllite is thrust northwestward on the Stoner overthrust over the formations of the Hanover-York Valley. Northeast of Hanover several small outlying areas (klippen) of Harpers phyllite that overlie the limestones are detached by erosion from the Stoner overthrust block. (See Pl. 29 A.)

Character and thickness.—The Harpers phyllite is prevailingly argillaceous in character. North of the Hanover-York Valley it is a dark-gray quartzose phyllite somewhat streaked with light gray bands and in places has quartzose beds, chiefly in its upper part. The bedding is nearly everywhere obscured by cleavage, the parting planes of which are shiny with fine mica. Its character in fresh exposure can best be seen in the gorge of Codorus Creek 2 miles north of York, and along the creek north of Glades to the river.

South of the Hanover-York Valley on the flanks of the Mount Pisgah, Kraft Mill, and Holtz anticlines, Harpers phyllite is more coarsely crystalline than in the Pigeon and Hellam Hills. It is a finely sparkling gray-green phyllite, in places banded with thin quartzose layers closely folded. Thick beds of green ferruginous quartzite in the phyllite have been locally mapped south of the Hanover-York Valley.

Because of the lack of observable bedding in the phyllite the thickness can only be approximated. On the southeast slope of the Pigeon Hills, at John Mummert School, where it lies in normal position between the Chickies and Antietam quartzites it is estimated to be 1,000 feet thick. At the west end of Mount Zion Hill where the Harpers is well exposed between clear outcrops of the enclosing quartzites in normal relation, the thickness determined from the width of outcrop and the dip of the adjacent quartzites is 800 feet. Its general thickness in the Hellam Hills in the Middletown quadrangle was estimated to be 1,000 feet.

Age and correlation.—The Harpers phyllite does not contain fossils in York County and its age is determined by Lower Cambrian fossils found in the conformably overlying formation, the Antietam quartzite. At Harpers Ferry, W. Va., where the formation takes its name, it underlies Antietam quartzite and overlies Weverton quartzite. These formations will be described in the discussion of the Lower Cambrian rocks north of the Triassic rocks.

ANTIETAM QUARTZITE

Distribution.—The Antietam quartzite is the uppermost formation of the Lower Cambrian quartzose series. It therefore forms the outer rim of the anticlinal mountains and hills made of Cambrian quartzites. It makes a narrow fluted band along the southeast flank of the Hellam and Mount Zion Hills, and around the southwest-plunging end of the Mount Zion anticline, and is there sharply offset 1 mile by faulting. A small outlying hill of the formation west of the Harrisburg road (U. S. 111), 2 miles northwest of York, is the extreme end of this anticline brought up between two diverging faults. It occurs in the Emigsville syncline south of Starview and in the Strickler anticline 1 mile south of Wrightsville.

The Antietam quartzite borders the northeast-plunging end of the High Rock anticline of the Pigeon Hills, surrounding Roth Church, and also borders in part the Harpers phyllite in the Gnatstown and Menges Mill anticlines of the southeastern part of the Pigeon Hills. It completely surrounds the Harpers phyllite of the Ambau anticline and spreads out into a fairly wide anticlinal area north and east of Mount Carmel School. It makes a line of narrow, discontinuous outcrops along a diagonal fault east of Nashville. It borders Pottery Hill, the conspicuous anticlinal hill of Harpers just south of the Hanover-York road, 1 mile west of West York.

South of the Hanover-York Valley it is present in the Stormy Hill School syncline, which also encloses the long narrow area of Vintage dolomite north of Porters Siding. It makes a relatively wide belt in the Jefferson syncline. In the southwest extension of this syncline it surrounds the area of Conestoga limestone at Wildasin Chapel. The largest area of Antietam quartzite south of the Hanover-York valley extends from a point north of Spry to East Prospect and a narrower band that continues northeastward to the Susquehanna River. The part east of Delroy lies on the north side of the East Prospect syncline, a deep embayment of Conestoga limestone with a bordering remnant of Vintage dolomite in places. An area of Antietam south of Margaretta Furnace partially surrounds a syncline of these limestones.

Character and thickness.—The Antietam quartzite is gray but weathers to rusty brown on bedding surfaces. The lower part of the formation is finer grained and has beds that are streaked with dark argillaceous matter, thus grading into the underlying Harpers phyllite. Hard blocky coarse-grained quartzite beds occur near the middle, and at the top there are granular ferruginous laminated quartzite beds that produce porous rusty blocks by weathering out of calcareous material. When the rock is split on these bedding planes it shows molds of fossils coated with yellow rust. The soil derived from weathering of these beds is a deep rich-red sand that contains residual iron ore.

The Antietam varies in coarseness of crystallization in different parts of the area. It is a grayish-green, fine to medium-grained quartzose phyllite in the Hellam and Pigeon Hills and the Strickler anticlines. In the region south of Mount Pisgah the rock is coarser grained and is speckled with brown biotite flakes and magnetite crystals. A similar rock with biotite and magnetite crystals occurs along the north side of the Jefferson syncline. It becomes finer grained along the strike to the southwestward.

A section of the formation on the south slope of the foothills of the Hellam Hills, 1 mile west of Wrightsville, is as follows:

Section of Antietam quartzite 1 mile west of Wrightsville

	Feet
Vintage dolomite	
Impure sandy dolomite weathering to porous sandstone	
Antietam quartzite	
Slabby quartzite with rusty partings and fossil impressions	40
Coarse granular porous-weathering fossiliferous quartzite	10
Quartzite banded with argillaceous streaks, weathering granular and white coated	150±
	200±
Harpers phyllite.	
Gray phyllite.	

South of Columbia, in the Lancaster quadrangle, a section of the upper beds of the Antietam, well exposed in the river bluff is as follows:

Partial section of Antietam quartzite south of Columbia

	Feet
Vintage dolomite	
Gray, knotty dolomite; basal beds siliceous and contain a small amount of sphalerite, and merge downward into pyritiferous calcareous sandstone.	
Antietam quartzite	
Fine-grained laminated gray quartzite and ferruginous quartzite composed of glassy quartz grains; contains pyrite and weathers rusty; top layer highly calcareous and full of pyrite and weathers to rusty siliceous skeleton..........................	10
Well-bedded fine-grained gray quartzite with highly ferruginous laminated beds containing fossils on bedding planes in lower part	30
Bluish schistose quartzite; no bedding observable and thickness not determinable.	

The Antietam is much thinner on the flanks of the anticlines of the Pigeon Hills, where it is also generally poorly exposed. It is estimated here to be less than 100 feet thick. It is well exposed on the north side of the Jefferson syncline north of Seven Valleys on the road to York New Salem. It here stands vertical but is much crushed and sheared, and the 150 feet thickness indicated by the exposure is probably much too thick.

Age and correlation.—The upper beds of the Antietam quartzite contain numerous fossils in the form of molds and casts, but they are generally too poorly preserved to be specifically determined. Places where fossils have been found in the Antietam quartzite and younger rocks are indicated by +F on the geologic map. Fragments of trilobites, mostly Olenellus, and the small shell, *Obolella*, are generally recognizable. At Emigsville and just west of Wrightsville Walcott identified in these beds *Camarella minor, Olenellus thompsoni,* Hall, *Obolella* cf. *O. crassa*, and *Hyolithes communis*. These forms are of Lower Cambrian age. The Antietam quartzite in South Mountain, in the western part of York County, will be described later, and has been traced southwestward along the mountain to Franklin County, Pa., where it is well exposed by Antietam Creek, from which it was named.

VINTAGE DOLOMITE

Distribution.—The Vintage dolomite is the oldest calcareous formation of the Cambrian system. It grades downward through calcareous quartzose beds into the Antietam quartzite. It therefore generally borders hills of Antietam quartzite throughout the area. The Vintage dolomite occupies a rather large area of lowland near Emigsville, on Codorus Creek and its tributary, in a syncline between the Antietam quartzite ridge north of Emigsville and the ridge northwest of Glades. It forms a narrow band along the south side of the Antietam quartzite on the south limb of the Hellam anticlinorium from Wrightsville to the southwestward-plunging end of the fold. On the south side of the York-Wrightsville valley a narrow band of Vintage dolomite, between the Antietam quartzite and the low hill of Kinzers formation, extends from Leiphart Mill southwest to Plank Road. Southwestward the Vintage is covered by the Stoner overthrust. A narrow band of Vintage dolomite borders the Antietam quartzite in the northern part of the East Prospect valley, but from a point east of East Prospect southward it is overlapped by the Conestoga limestone. Small areas of Vintage are exposed on Cabin Creek and in the valley 1 mile south of Margaretta Furnace.

The dolomite area at Saginaw, on the west bank of Susquehanna River, is part of a larger area that borders the Antietam quartzite in the Marietta anticline in Lancaster County, east of the river. This anticline lies north of the Chickies overthrust, and in that area Kinzers formation is not present and dolomite of Vintage type is directly overlain by dolomite of Ledger type. These two dolomites correspond to the Tomstown dolomite of the Great Valley sequence which is present chiefly in the northern part of the county, north of the Triassic basin, and will be described with the Tomstown dolomite.

One of the largest areas of the formation, over 1 mile wide, forms an arc around the Antietam quartzite at the east-plunging end of the Pigeon Hills anticline, east of La Bott. The Vintage borders the Antietam quartzite in several faulted anticlinal folds from Nashville southwestward to Mt. Carmel School, and forms the valley southward to the Stoner overthrust. The Vintage dolomite is also exposed at two places in the Sprenkle School anticline within the wide area of Kinzers formation northeast of Spring Grove. North of Hanover it borders the Antietam quartzite on the south side of the Pigeon Hills, and swings around the westward-plunging ends of two small anticlines of the quartzite at the border of the county and in the adjacent part of Adams County. A narrow area of Vintage dolomite associated with the Antietam quartzite occurs in the syncline 1 mile northeast of Porters Station. A still smaller area is exposed beneath the Conestoga limestone in the Jefferson syncline north of Seven Valleys.

Character and thickness.—The Vintage dolomite may be divided into two divisions. The lower part is chiefly a blue knotty, "mud lump" dolomite. At its base is a white quartzose marble that grades downward into the underlying Antietam quartzite, but is seldom exposed. This basal bed is exposed in a small ravine on the east side of Susquehanna River, 1 mile south of Columbia, in Lancaster County. The blue knotty dolomite is well exposed in a quarry south of Wrightsville, on the south bank of Kreutz Creek, where the rock was quarried for construction of the highway bridge completed in 1930 across the river on Highway U. S. 30. The dolomite exposed is about 100 feet thick, in part well bedded and in part massive with no visible bedding. Other outcrops of the lower knotty dolomite occur at several ravines along the foot of the hills on the south side of the York-Wrightsville Valley, at Plank Road, and in the valley of Codorus Creek just south of where the creek enters its rocky gorge, 2 miles north of York.

The higher beds of the formation are mostly pure fine-grained limestone, finely banded or mottled by wavy dark layers. These beds are well exposed in many small abandoned quarries in the vicinity of La Bott. These upper pure beds have not been observed in the eastern part of the area and probably are very thin or absent there.

In general the Vintage dolomite is poorly exposed because it is more soluble than the enclosing beds, and forms lowlands, in large part covered by quartzite wash, between high hills of Antietam quartzite and lower hills of shale of the Kinzers formation. The lower dolomite of the formation weathers to a characteristic maroon-red granular clay which covers the lower slopes of the Antietam quartzite hills.

Because of poor exposures it is difficult to determine the thickness of the formation. In the La Bott area, where the formation dips gently away from the plunging end of the Pigeon Hills anticline without duplication of beds by minor folding, the thickness computed from the width of outcrop and the general dip is 800 feet. In the narrow bands of the formation west of Nashville and southwestward, the thickness is apparently not over 500 feet. On the south side of the York Valley, southwest of Stonybrook, and eastward into Lancaster County southeast of Columbia, the Vintage is very thin, probably not over 200 feet, and the upper purer limestones of the formation are apparently not present. The fact that both the Vintage and overlying Kinzers formations are very thin and all members are not present in the extreme southeastern exposures suggests the shallowing of the sea and probable nearness of the shore in this direction.

The most complete exposure of the Vintage dolomite in the region is in the vicinity of Emigsville. A composite section made from exposures in quarries and other isolated outcrops is as follows:

Composite section of Vintage dolomite south of Emigsville

	Feet
Top of formation concealed by overthrust fault	
Concealed (some beds of white siliceous chalky marble weathering to buff tripoli near middle, and some light-gray jointed dolomite in upper part. Estimated	320±

Pure fine-grained mottled dark-blue and white limestone with some dolomitic bands and lumps (probably same as the Salterella-bearing beds near La Bott)	40±
Coarse crystalline white and black brecciated marble and dark-blue glistening dolomite	180±
Light-blue limestone with coarser dolomite blebs and blue and white streaked limestone with dolomite mud-lump structure; weathers knotty and dirty gray	80
Impure blue and gray mottled sheared dolomite; weathers dirty gray.	40
Dark-gray sparkling knotty dolomite with lighter gray coarsely crystalline blebs and stringers and thin bands alternately dark and white; top bed, mud-pellet layer	15
Dark fine-grained dolomite finely banded and showing finely conglomeratic character on weathering	20
Massive light-gray fine-grained dolomite	30
(The three units above described are exposed in a quarry in western part of Emigsville)	
Light-gray dolomite with coarser dolomite blebs	35
Blue and white laminated marble, with fossiliferous blue limestone at top	90
Concealed (fragments of slabby light-blue limestone with shaly partings). Estimated	350±
Spotted dolomite pitted with flat holes (pebbles?) on weathering (quarry southeast of Emigsville)	25
Covered. Estimated	200±
(The basal beds are not here exposed but elsewhere are seen to be white to pinkish cream-colored laminated fine-grained marble becoming siliceous downward and merging into the Antietam.)	
	1,425±

Rusty quartzite in Pennsylvania Railroad cut at Emigsville (Antietam).

The estimated thicknesses in the concealed portions may be greatly in error and the actual total thickness is believed to be not much over 1,000 feet.

The section of the Vintage dolomite on the south side of the York-Columbia valley is much thinner, as shown at the ravine on the east side of the Susquehanna 1 mile south of Columbia:

Section of Vintage dolomite 1 mile south of Columbia

	Feet
Blue calcareous slate and gray slate (Kinzers)	
Blue knotty dolomite	10±
Concealed in valley, estimated	40±
Very massive dolomite	20
Knotty gray dolomite; weathers thin bedded	140±
(Basal layer containing small amounts of sphalerite and galena grades downward into pyritiferous calcareous quartzite)	
	210±
Calcareous grandular quartzite (Antietam)	

The top of the Vintage dolomite is well exposed in the Pennsylvania Railroad cut west of the quarry of the Universal Gypsum & Lime Co., formerly the Palmer Lime & Cement Co., in West York. These beds are of especial interest because they contain cystid plates. The section is as follows:

Section of upper part of Vintage dolomite southwest of West York

	Feet
Shale (Kinzers)	
Gray dolomite; weathers dirty	10±
Mud-lump dolomite and impure dark and light dolomite with coarse crystalline specks	12
Impure dolomite; weathers to concentric banding	5
Crumbly dolomite; weathers dirty	8
Light-blue limestone; weathers white and blue mottled with dark impurities. Surface weathers pitted and "worm eaten." Contains cystid plates which weather in relief	7
Blue fine-grained dolomite; weathers dirty buff	10
	52

Age and correlation.—The Vintage dolomite has yielded a few fossils which include fragments of trilobites, a few shells, a phyllopod, and cystid plates. *Salterella conica* was found in pure limestone beds in the upper part of the formation southeast of La Bott and in a few other places in that vicinity. Cystid plates of unidentified forms occur in limestone beds interbedded with dolomite in the Pennsylvania Railroad cut south of the area of Antietam quartzite in Pottery Hill.

The fossils that have been identified from the formation in this and nearby areas are of Lower Cambrian age. The Vintage dolomite immediately underlies shale and limestone of the Kinzers formation which have a large fauna of Lower Cambrian age. The formation was named from its exposure[30] along the Pennsylvania Railroad at Vintage station, east of Lancaster.

KINZERS FORMATION

Distribution.—The most characteristic feature of the Kinzers formation is its hill-forming hard members—the shale at its base and the impure calcareous sandstone at its top. These beds generally make low ridges and in places prominent hills. A narrow limestone valley formed by the middle member generally lies between the parallel hills of these harder members. The shale at the base has been mapped separately throughout York County. In the vicinity of Penn Grove and in the areas north of East Prospect and northeast of Plank Road, this shale is the only part of the formation present. The sandy and earthy beds at the top of the formation have been mapped where they make a conspicuous ridge and in other places where such mapping is essential in solving the structural relations.

The Kinzers formation with its two lines of hills and narrow intervening valley lies on the north side of the York-Wrightsville valley from Susquehanna River to York. Both the shale and sandstone hills here are very low, and the sandstone hill is the more conspicuous of the two. Near Hellam, Highway U. S. 30 is located on it. The Kinzers formation is repeated by faulting north of Campbell Station.

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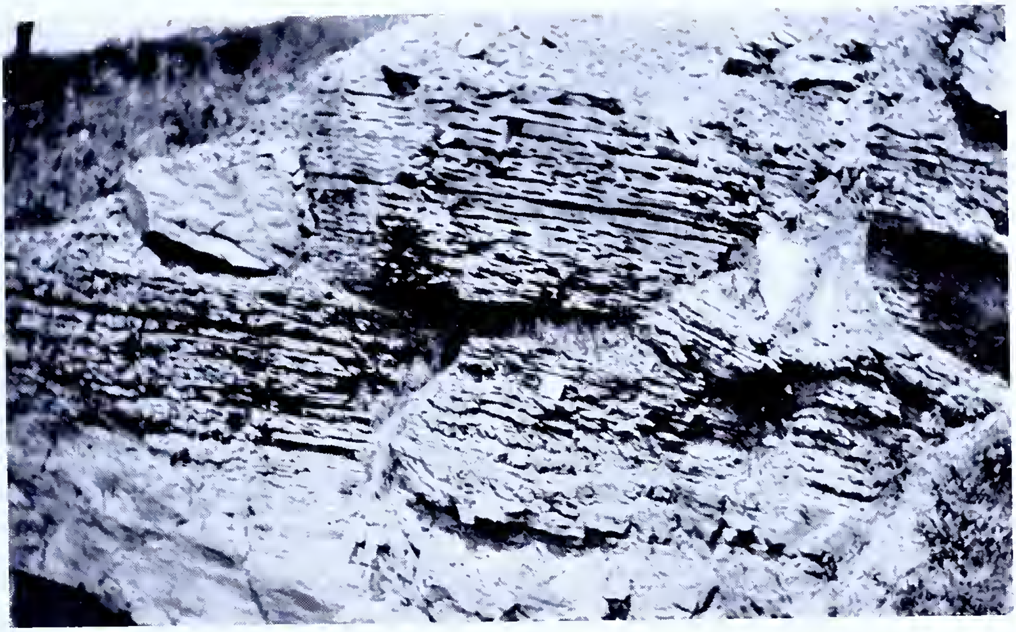
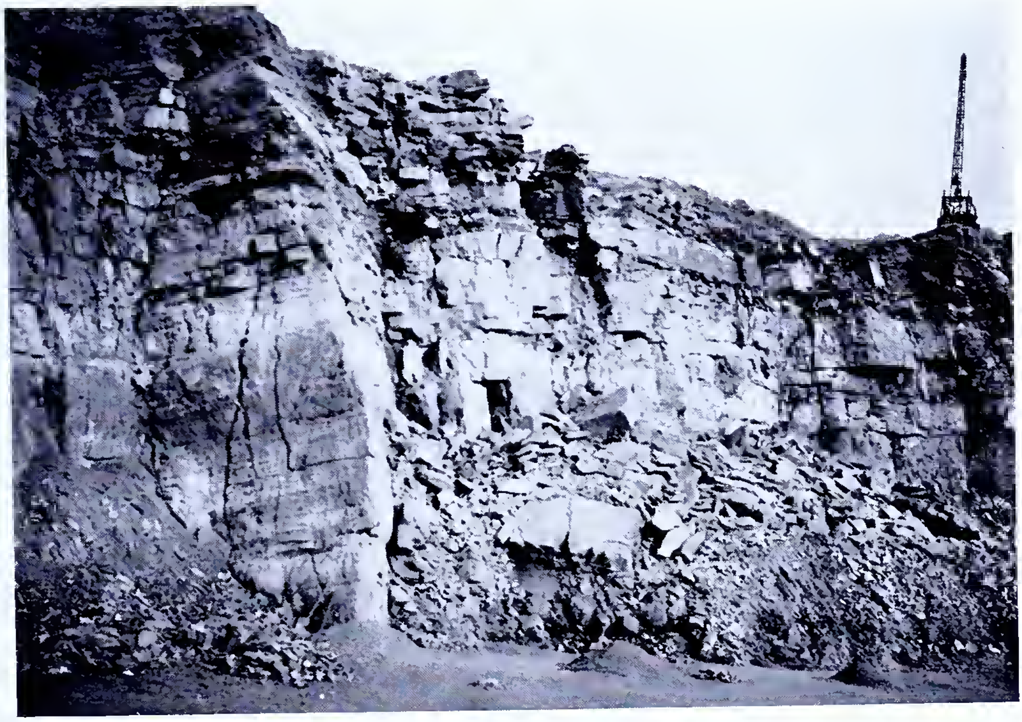
[30] Stose, G. W., and Jonas, A. I., op. cit. (Lower Paleozoic section of southeastern Pennsylvania), p. 362, 1922.



A. Lenticular sandy limestone weathered to earthy sandstone in upper part of middle member of the Kinzers formation. ½ mile south of Thomasville.



B. Tomstown dolomite and overlying lower beds of the Waynesboro formation.
Strayer and Lefever Bros. quarry, 2 miles north of Dillsburg

North and northwest of York the basal shale makes prominent ridges crossed by the highway to Emigsville but, due to faulting, the ridges are not continuous. The shale makes several hills in the western part of the York valley, west of York, near the border of the overlapping Triassic rocks. Prominent detached hills of the upper sandstone member northwest of York are the sites of Greenmount Cemetery and of Farquhar Park.

South of West York on both sides of West Branch of Codorus Creek, the Kinzers formation occurs in several folds broken by faults. The quarry of the Universal Gypsum & Lime Company, formerly Palmer Lime & Cement Company, is located in the middle member of the formation south of a hill of the lower shale member. The Eli Zinn quarry on the north side of Codorus Creek, just south of York, is also in the middle member with the upper sandstone member forming the top of the quarry and the hill to the north on which Highland Park is located.

The three-fold character of the formation is best displayed near Thomasville, where the members form wide bands due to low dips on the plunging end of the High Rock anticline of the Pigeon Hills. The upper sandstone member makes the prominent hill southeast of Thomasville, and the lower shale member the arcuate hill southwest of Thomasville which loops around the plunging end of the High Rock anticline. The quarries of the Thomasville Stone & Lime Co. and of the J. E. Baker & Co. are in the pure limestones of the middle member.

An irregular belt of hills of the Kinzers formation enclosing a narrow valley of Vintage dolomite extends from south of West York southwestward to Spring Grove. The anticlinal structural of this hill could be worked out only by mapping separately the shale at the base of the Kinzers. The two overlying members are not separated because the upper sandstone beds are thin. The Kinzers formation is preserved on the flanks of several minor anticlines, such as those north of Nashville and at Menges Mills, and nearly surrounds the anticline north of Iron Ridge. The shale at the base has been separately mapped also in these areas.

Character and thickness.—The Kinzers formation, as stated, is composed of three distinct members. The lower member is a black to dark-gray shale. The middle member is largely limestone of variable composition. Some of this limestone is very pure high-calcium rock, and is extensively quarried by two companies at Thomasville, one in West York, and two north of the shale hills 2 miles west of West York. Many of the limestone beds have reticulate argillaceous or earthy layers inclosing rounded or lenticular masses of white crystalline limestone, producing a spotted rock, called "leopard rock." On weathering the impure layers stand in relief and some form a reticulate earthy network. (See Pl. 15 A.) This peculiar structure is apparently of organic origin related to Archeocyathid reefs which are present in some of the purer limestones of the formation in the Eli Zinn quarry on the east face of Greenmount Hill and at the S. Forry Laucks quarry. Better preserved fossil algae reefs of similar type occur in rocks of the same age near Austinville, Va.[31]

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[31] Stose, G. W., and Jonas, A. I., A southeastern facies of Lower Cambrian dolomite in Wythe and Carroll Counties, Va.: Va. Geol. Survey, Bull. 51-A, pp. 10-18, 1939.

Some of the pure beds have a conglomeratic appearance produced by partial recrystallization. These beds contain rounded residual masses of finely crystalline dark limestone enclosed in light-gray to white coarser-grained recrystallized marble. Beds of coarse conglomerate composed of marble fragments in a finer matrix are also present, and may be seen in the quarry of the York Valley Lime & Stone Co., 6 miles northeast of York. Some beds of pure limestone have been in part altered to coarse-grained dolomite, the replacement taking place along fractures and spreading irregularly into the mass away from the fracture. The upper member of the formation is usually an earthy or fine quartzose limestone banded with dark argillaceous layers. These beds weather to a buff, dense, tough tripoli, porous fine sandstone, or dark, dry, earthy-banded shale. Fossils have been found in this weathered rock at most of its outcrops. These sandy beds are most conspicuously developed southeast of Thomasville, where they make a prominent hill.

The upper sandy beds that make a low ridge on the north side of the York-Wrightsville valley extend eastward into Lancaster County. At the time of publication of the reports on the Middletown and Lancaster quadrangles these sandy limestones were thought to be the basal beds of the overlapping Conestoga limestone, and were so shown on the maps in those reports.[32] Fossils recently collected from these beds in York County prove them to belong in the Kinzers, and the corrected mapping of these beds in the Middletown quadrangle is shown on the geological map of York County. (See Pl. 1.)

In the Lancaster area the Kinzers formation is 150 to 200 feet thick. The character of the beds in that area is shown in the following composite section derived from exposures at Kinzers, the type locality 13 miles southeast of Lancaster, and at Rohrerstown:

Composite section of Kinzers formation in Lancaster and New Holland quadrangles

	Feet	
Ledger dolomite.		
Massive granular gray dolomite		
Kinzers formation.		
Upper member		
Impure white marble with siliceous partings; weathers to tough tripoli	20±	
Sandy dolomite; weathers to tough hard porous fine-grained standstone	5	
Concealed	20±	
		45±
Middle member		
Dark-blue limestone with wavy argillaceous partings and thin gray dolomite	30±	
White-spotted dark earthy limestone ("leopard rock")	10	
Tough sandy blue dolomite; weathers buff and somewhat ribbed (fossiliferous)	20	
Dense blue impure limestone with nodular spots of pure limestone ("leopard rock")	6	
Wavy-banded blue limestone with fine argillaceous laminations	10	
		76±

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[32] Stose, G. W., and Jonas, A. I., op. cit (Middletown quadrangle Pa.), 1933; (Lancaster quadrangle), 1930.

Lower member		
Dark fissile shale	35-70	
Earthy blue dolomite weathering to buff or orange-colored tripoli or porous sandstone (fossiliferous)	5	
		40-75
		161 to 196

Vintage dolomite
Massive light-gray dolomite

In the reports on the New Holland[33] and Lancaster[34] quadrangles the writers recognized the 3-fold division of the formation but did not subdivide it on the map.

Another nearly complete section of the Kinzers formation is exposed north of Wrightsville, where the pure marble of the middle member has been extensively quarried. In the report on the Middletown quadrangle[35] these pure beds were included in the Ledger dolomite, but are now known to be part of the Kinzers.

Revised composite section of Kinzers formation and overlying limestones north of Wrightsville

		Feet
Conestoga limestone		
Argillaceous limestone conglomerate and argillaceous banded blue limestone, and thick granular crystalline limestone Black argillaceous limestone and thin shale, ripple marked Two-foot bed of marble Conglomerate of dark slabby limestone pebbles and large (6″) angular white marble masses in black slaty matrix		200±
Concealed (Slaty limestone with shale partings in part; large spring near base)		220±
Ledger dolomite		
White to blue mottled coarsely crystalline dolomite		105±
(In quarry west of road on upland, 50 feet of dark argillaceous to earthy limestone, closely folded, makes a horse in quarry.)		
Kinzers formation		
Upper member		
Dark slaty argillaceous limestone and hackly dark dolomite	10±	
Thin fissile to platy black earthy shale	5	
Earthy-banded blocky sandy limestone, weathers to hard, quartz-grain sandstone and porous sandstone pitted by dissolved limestone pebbles	20±	
Concealed	35±	
Black fissile shale and slaty limestone	40±	
Slaty blue limestone and knotty blue dolomite, rough bedding surfaces, carbonaceous partings	25	
		135±

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[33] Jonas, A. I. and Stose, G. W., op. cit. (New Holland quadrangle), pp. 11-12, 1926.

[34] ———, and ———, (Lancaster quadrangle), pp. 26-30, 1930.

[35] Stose, G. W., and Jonas, A. I., op. cit. (Middletown quadrangle), pp. 27-29, 1933.

Middle member		
Dark and light spotted crystalline marble ("leopard rock")	10	
Massive-bedded white coarsely crystalline marble	30±	
Light-gray dolomite (horse in quarry)	5	
Very massive-bedded mottled white coarse crystalline marble; some limestone conglomerate in middle; thinner bedded at base	50±	
Blue limestone	10	
Concealed	80±	
		185±
Lower member		
Concealed	70±	
Dark shale (forms hill)	30±	
		100±
		420±
Vintage dolomite		
Dark knotty dolomite		

Many detailed sections of parts of the Kinzers formation given in the report on the Hanover-York district are not repeated here.

Age and correlation.—The Kinzers formation is the most fossiliferous formation in York County. Fossils have been collected from all three members of the formation. The lowest fossiliferous horizon is in a few feet of earthy beds at the base of the shale of the lower member. Fossils obtained by the writers and C. E. Resser from these beds at Donnerville, Lancaster County, have been identified by Resser as *Bonnia senecta ?* (Billings) and *Olenellus* fragment.

The shale of the lower member is highly fossiliferous, especially in the vicinity of Lancaster, and is noted for its trilobites. (See Pl. 31.) A complete list with descriptions and plates of fossils from the shale member in Lancaster and York Counties is given by Resser and Howell in a recent publication.[36] These fossils were collected from four localities in the shale member in Pennsylvania, three of which are in Lancaster County. The fourth is located 2 miles north of the square in York, and the fossils were collected largely by C. D. Walcott and C. Schuchert many years ago. The locality is no longer available for collecting. Most of the species occur also at the localities near Lancaster. The fossils found 2 miles north of York are as follows:

Lepidocystis wanneri Foerste
Salterella acervulosa Resser and Howell
Hyolithes wanneri Resser and Howell
Eoagnostus roddyi Resser and Howell
Olenellus similaris Resser and Howell
Olenellus alius Resser and Howell
Olenellus wanneri Resser and Howell
Paedeumias glabrum Resser and Howell
Paedeumias yorkense Resser and Howell
Paedeumias eboracense Resser and Howell
Wanneria walcottana (Wanner)
Esmeraldina macer (Walcott)
Bonniella yorkensis Resser and Howell
Anomalocaris lineata Resser and Howell

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[36] Resser, C. E., and Howell, B. F., Lower Cambrian *Olenellus* zone of the Appalachians: Geol. Soc. Am. Bull., vol. 49, pp. 205-248, 1938.

This fauna is regarded by Resser and Howell as the equivalent of that from the lower part of the Parker slate exposed in the Parker quarry, near Parker Cobble, Vt. The Parker slate was first described and named by Keith.[37] Schuchert[38] gives a more complete description of the formation, including the impure dolomites and reef limestones above the slate, and lists the fossils from the Parker slate.

Resser and Howell[39] correlate the shale member of the Kinzers formation with the Rome formation on the basis of the fact that the Rome formation also contains *Olenellus* and *Hyolithes*. The writers' objection to this correlation is fully stated in their paper[40] on the Austinville area, Virginia, where a fossil-bearing series of beds whose fauna, lithology, and stratigraphic position are comparable with the Kinzers formation, lies between dolomites equivalent to the Vintage and Ledger respectively.

Fossils were collected by the writers from earthy limestones at the base of the middle member, just above the shale, near Myers Mill, from an abandoned quarry 2 miles northwest of York, and at Rohrerstown in Lancaster County. Fossils collected from these localities by the writers and others have been identified by Resser as follows:

Nisusia festinata (Billings)
Kutorgina cingulata (Billings)
Paterina bella (Billings)
Kootenia marcoui (Whitfield)
Dawsonia parkeri (Walcott)
Rustella edsoni Walcott
Yorkia wanneri Walcott
Ptychoparella sp.
Hyolithes sp.
Olenellus sp.
Bonnia bubaris Walcott
Bonnia capito Walcott
Cystid plates
Salterella sp.

Fossils collected by the writers in higher argillaceous limestone of the middle member at the quarry of the York Valley Lime & Stone Co., 6 miles northeast of York, were identified by Resser as *Kochiella*, *Agnostus*, *Ptychoparella* [*Ptycoparia*], *Prozacanthoides*, *Nisusia festinata* (Billings), *Obolus* or *Lingulella* sp., and a phyllopod resembling *Schaefferia*. G. A. Cooper and the writers collected *Kootenia* from these beds.

The purer limestones and marbles of the middle member, extensively quarried in the area, are generally unfossiliferous, but archeocyathid reefs have been observed in these beds by the writers at the S. Forry Laucks quarry, just south of Lauck School, at Eli Zinn quarry on the north slope of Greenmount Cemetery Hill, and in the quarry of the Universal Gypsum & Cement Co. in West York. Similar Archeocyathid reefs occur in pure marble and limestones of the same age near Austinville, Virginia.[41]

Fossils were collected by the writers from the earthy sandy beds in the upper member of the formation at many places in the area, which are indicated on the geologic map. Fossils collected ¼ mile north of Strickler Station were identified by Resser as *Agnostus, Bonnia, Nisusia,* an unidentified phyllopod, and Salterella. Those collected on the road to Highmount north of Highway U. S. 30, 1½ miles northeast of the center of Hellam, were identified as *Eoagnostus,* cystid plates, and an alga resembling *Morania.* Schuchert reported from this locality also *Acrothele decipiens.* The largest collection of fossils from this horizon came from exposures on the Western Maryland Railroad, south of the quarry of the Thomasville Stone & Lime Co. These were identified by Resser as *Syspacephalus?, Kochiella, Nisusia, Hyolithes,* cystid plates, and a *Discina*-like form. *Nisusia, Yorkia,* and undetermined trilobites were collected at Sunnyside station on the York electric railroad half a mile southwest of Bair. In the limestone quarry of Roy Bittinger, at the railroad southwest of Spring Grove, good specimens of trilobites were collected and identified by J. Bridge as *Bonnia* cf. *B. capito.* Paterina was also collected here. In a small quarry 1 mile southeast of Thomasville, *Nisusia, Kootenia,* and *Ptycoparella* were collected. In the quarry on the east side of Greenmount Cemetery Hill *Nisusia, Kutorgina,* and cystid plates were collected, and 2 miles southwest of West York *Periomella Yorkensis,* Resser, and *Eoagnostus roddyi,* Resser and Howell, were obtained.

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[37] Keith, A., Stratigraphy and structure of northwestern Vermont: Washington Acad. Sci. Jour., vol. 22, p. 371, 1932.

[38] Schuchert, C., Cambrian and Ordovician stratigraphy of northwestern Vermont: Amer. Jour. Sci., vol. 25, pp. 362-364, 1933.

[39] Resser, C. E., and Howell, B. F., op. cit., pp. 205, 215, 221, 1938.

[40] Stose, G. W., and Jonas, A. I., op. cit. (Lower Cambrian dolomite in Wythe and Carroll Counties, Virginia), pp. 20-22, 1939.

[41] Stose, G. W., and Jonas, A. I., op. cit. (Lower Cambrian dolomite), pp. 10-18, 1939.

Trilobites and other fossils were collected 20 years ago by Atreus Wanner, Charles Schuchert, and C. D. Walcott from sandy shale near the top of the Kinzers formation in the northern part of York. These fossils were reported from three localities: in Grant Alley near the plant of the York Gas Co., at Cutcamp's quarry and Smith lime kiln north of Cottage Hill Road, and at Penn and North Streets. Only the Grant Alley locality can be studied at present because of city development, and from this locality the writers have recently collected fossils. The fossils from this horizon, identified by Resser, are as follows:

Acrothele decipiens (Walcott)
Acrothele yorkensis (Walcott)
Poliella [Bathyuriscus] bala (Walcott)
Agnostus sp.
Ptychoparella sp.
Chancia n. sp.
Chancelloria yorkensis (Walcott)
Prozacanthoides sp.
Cystid plates

In the report on the Middletown quadrangle[42] the writers described these fossils as coming from the Ledger dolomite because at that time Resser considered them to be high in the Lower Cambrian or in the Middle Cambrian. Similar fossils, including *Poliella bala,* were collected by the writers from the upper part of the Kinzers formation in the Pennsylvania Railroad cut at Dillerville, west of Lancaster.

All the fossils collected from the Kinzers formation indicate Lower Cambrian age. The formation was named from Kinzers station, on the Pennsylvania Railroad, 14 miles east of Lancaster, where the relation to the underlying Vintage dolomite is well shown.

A fossiliferous series lithologically and faunally similar to the Kinzers formation occurs in a small area south of Austinville, Va., on the southeastern edge of the Great Valley, and the name Kinzers formation has been recently extended[43] to these beds. The fossils collected from the three members are listed and the fauna from Fossil Point in the Virginia area is stated by Resser to be the same as that occurring in the middle member of the Kinzers formation in the vicinity of York. The limestone at Fossil Point is a pure white crystalline limestone with thin earthy-weathering layers in which Archeocyathid reefs occur at several horizons and in which Lower Cambrian brachiopods and trilobites are very abundant. Fossils collected from the top of the middle member of the Kinzers formation in the Virginia area are said by Resser to be the same fauna as that from the uppermost earthy weathering sandstones of the upper member near York. Resser states also that the fauna of the Kinzers near York and southeast of Austinville, Va., is the same as that from the Forteau[44] limestone of Bonne Bay, Newfoundland.

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[42] Stose, G. W., and Jonas, A. L., op. cit. (Middletown quadrangle), p. 29, 1933.

LEDGER DOLOMITE

Distribution.—The Ledger dolomite overlies the Kinzers formation but is not everywhere present above the Kinzers in York County because the Conestoga limestone in places overlaps on the Kinzers formation. The best exposures of the Ledger are in the area north of York and southwest in a broad flat valley nearly to Thomasville. Another large area of Ledger but with few outcrops makes the lowland east, south, and southwest of Spring Grove. Narrow lenticular bands of the formation are exposed north of Hellam station and north of Wrightsville between the top of the Kinzers and the base of the overlapping Conestoga limestone. In the dolomite that overlies the Antietam quartzite at Saginaw, near the Susquehanna River, Kinzers formation is not present, and Ledger type of dolomite rests on Vintage type. The dolomite is therefore classed as Tomstown and will be described with that formation, which lies chiefly north of the Triassic basin.

Character and thickness.—The Ledger is everywhere a coarse granular pure dolomite, free from silica and other impurities. The dolomite is very thick bedded and coarse grained and of light-gray color, mottled in places with dark grains and spots. It weathers to a characteristic deep-red granular soil. A chert horizon occurs near the top of the formation and has been mapped from West York to beyond Botts. Residual porous masses of this chert occur in the deep-red dolomite soil and in places are concentrated so as to make hills. The beds above the chert horizon are deeply weathered but are of the same character as the dolomite below the chert. The dolomite is so pure that it is extensively quarried elsewhere in the region for magnesian products, but it has not been utilized for this purpose in York County. The nearest place where it was quarried for magnesian products is at the old quarry of the Dolomite Products Co. at Shreiner, 3 miles northwest of Lancaster.

The total thickness of the formation can not be determined in this area as the top is not exposed. North of Wrightsville only about

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[43] Stose, G. W., and Jonas, A. I., op. cit. (Lower Cambrian dolomite), pp. 20-22, 1939.

[44] Schuchert, C., and Dunbar, C. O., Stratigraphy of western Newfoundland: Geol. Soc. Am. Mem. 1, pp. 18-32, 1934.

100 feet of the formation is present. East of Thomasville, where the formation is much wider, it overlies the sandy upper member of the Kinzers formation, which dips east about 10°, but the exposures of the Ledger dolomite are very infrequent and its dip is uncertain. It is estimated that the chert horizon is about 700 feet above the base, and the total thickness of the formation is about 1,000 feet.

Age and correlation.—No fossils have been found in this formation in this region. Fossils previously described as occurring in the Ledger dolomite are now known to come from beds in the Kinzers formation. The pure limestones with impure shaly beds from which the fossil shell *Nisusia festinata* (formerly mis-identified) was collected by the writers near Bittinger, northwest of Hanover, described[45] as Ledger in earlier reports, are now assigned to the Kinzers formation.

The formation was named from the village of Ledger in Lancaster County. North and northeast of Lancaster it is overlain by the Elbrook formation of Middle Cambrian age.

The Ledger is believed by the writers to be the equivalent of the upper part of the Tomstown dolomite of the Great Valley sequence (see Fig. 3 and chart, pp. 34, 35), and the Vintage to be the equivalent of the lower part of the Tomstown. The Tomstown may be divided into an upper and lower part on the basis of lithology and these divisions resemble the Vintage and Ledger dolomite respectively. The Kinzers formation which lies between these dolomites in the area south of the Pigeon and Hellam Hills and the Chickies overthrust is not found in the Tomstown dolomite of the Great Valley sequence in Pennsylvania and Maryland nor in the equivalent Shady dolomite to the southwestward. The fossiliferous facies of Lower Cambrian dolomite was deposited in an area on the southeast side of the main Appalachian geosyncline and has been carried northwestward by thrust faulting. The southeastern fossiliferous facies of the Lower Cambrian dolomite (Shady) occurs also south of Austinville, Virginia, as has been mentioned.

Ordovician (?) system

CONESTOGA LIMESTONE

Distribution and unconformable relations.—The Conestoga limestone is the only formation of probable Ordovician age present in York County southeast of the Triassic rocks. This limestone generally makes valleys and occupies the larger part of the broad flat lowland from York northeastward to Wrightsville, and underlies the larger part of the city of York. An anticline, south of West York, separates this area from another large area of Conestoga limestone, which extends southwestward from Hope School to beyond Bair and ends south of Spring Grove. Hanover is in the midst of a third large area of Conestoga limestone which extends from the southern foot of the Pigeon Hills nearly to the Stoner overthrust on the south. East of Hanover narrow belts of this limestone form valleys bordered by

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[45] Stose, G. W., op. cit. (Fairfield-Gettysburg folio no. 225), p. 8, 1929.
Knopf, E. B., and Jonas, A. I., op. cit. (McCalls Ferry), p. 54, 1929.
Stose, G. W., and Jonas, A. I., op. cit. (Lancaster atlas), p. 32, 1930.

Harpers phyllite, and the area at Penn Grove is entirely surrounded by hills of the phyllite.

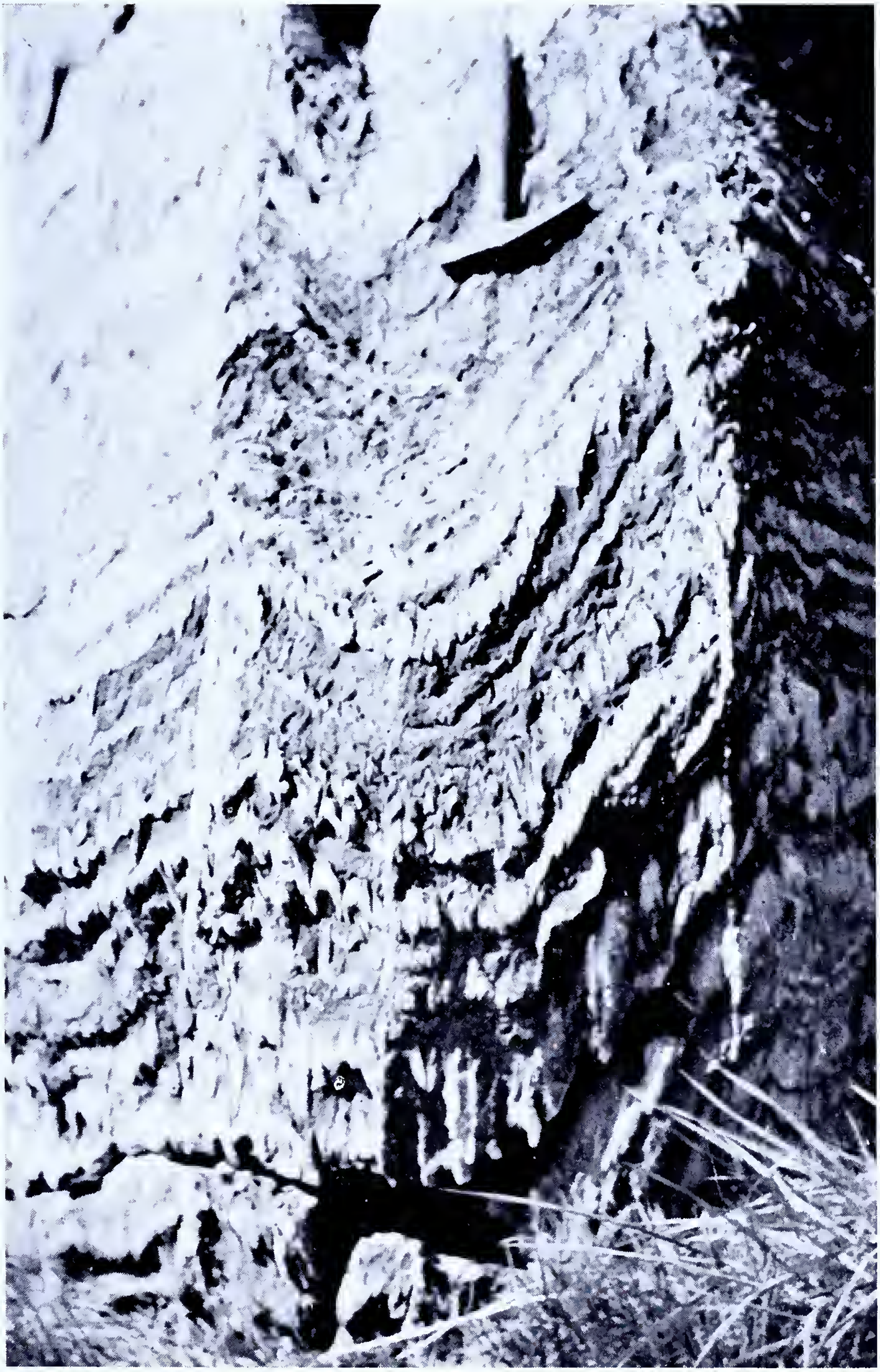
Because the Conestoga limestone is unconformable to the underlying formations, it transgresses them in outcrop. In most places on the north and south sides of York valley, northeast of York, it rests on the Kinzers formation, but north of Hellam Station and in the quarries north of Wrightsville it overlies Ledger dolomite. On the south side of the Hanover lowland and at Penn Grove it overlies the lower shale member of the Kinzers, but north of York Road it appears locally to overlap the Vintage dolomite onto the Antietam quartzite.

In the northern part of the East Prospect syncline, Conestoga limestone rests on the lower shale member of the Kinzers formation and overlaps the Kinzers and the Vintage dolomite onto the Antietam quartzite in the southern part of the syncline. Small outcrops of black slate in the lowland 1 mile south of Margaretta Furnace may represent the Conestoga limestone.

Three narrow, flat-bottomed valleys within the Antietam quartzite area on the south side of the Mount Pisgah anticline—one south of Delroy, another along Kreutz Creek south of Golden, and a third north of Ore Valley—are believed to be underlain by limestone. These valleys contain no outcrops but are bordered by limonite ore pits and contain limestone soil and small black slate fragments believed to be derived from impure limestone. This limestone is presumably Conestoga limestone because the black calcareous slate fragments found in the soil are a characteristic weathering product of this formation.

The Conestoga limestone occupies two narrow valleys in the Jefferson syncline. The northern and longer valley extends from Middle Branch of Codorus Creek southwestward to Valley Junction. The limestone overlies Antietam quartzite, except north of Smyser Station where a small area of Vintage dolomite is exposed between the Conestoga limestone and the Antietam quartzite. From Smyser Station southwestward to Sinsheim the southern valley of Conestoga limestone is separated from the northern one by an anticline of Antietam quartzite. The Martic overthrust forms the south border of this area of limestone. Another syncline to the southwestward, in strike with this syncline, occurs along West Branch of Codorus Creek and probably contains Conestoga limestone overlying Antietam quartzite, except where it is cut out on the south side by the Martic overthrust.

Character and thickness.—The Conestoga limestone in the type locality near Lancaster is largely a thin-bedded crystalline blue limestone with numerous dark argillaceous partings, closely folded and with pronounced slaty cleavage that obscures the bedding in many places. In the lower part of the formation are thick-bedded granular limestones, with beds of coarse limestone conglomerate, and in many places beds that contain numerous rounded glassy quartz grains and weather to a porous friable sandstone. Because the limestone is generally closely folded, its thickness cannot be measured. It is estimated to be more than 500 feet thick and is probably much thicker where more fully preserved in Lancaster County.



Closely folded Conestoga limestone in Wm. H. Grothe Brick Co.'s clay pit, south of York. Cleavage dips 60° SE, photograph tilted. Looking west.

In York County the Conestoga limestone is very poorly exposed, and nowhere is there a continuous section. In the valley east of York there are many outcrops of thick-bedded granular limestone, some beds of which contain quartz grains and coarse conglomerate, and these beds represent the lower part of the formation. The more plentiful outcrops of thin-bedded blue limestone represent the upper part of the formation. Thin beds of black graphitic shale occur as partings within the limestone, especially near the south edge of the valley. The best exposures of Conestoga limestone in the county are in the clay pits of the brick plants in the southeastern part of York, where the residual clay soil has been stripped from the limestone over large areas. In the Wm. H. Grothe Brick Co.'s pit, 1 mile west of Plank Road, the rock is largely thin-bedded platy blue micaceous limestone with some thicker granular crystalline limestone in beds up to 3 inches thick, with wavy argillaceous partings, and beds of calcareous mica schist up to 20 feet thick which are largely weathered to macaceous sandy clay. The beds are closely folded (see Pl. 16) and the axial planes of the folds are overturned so that the beds dip southeast. The slaty cleavage dips 60° southeast. These beds are typical of the upper part of the formation. The lower part of the formation is exposed in an abandoned clay pit half a mile to the northwest of the Grothe pit, within the York city limits. The beds are thick gray crystalline limestone with scattered glassy quartz grains and thicker beds of conglomerate composed of granular limestone pebbles in a fine conglomerate matrix, interbedded with thin-bedded blue micaceous limestone. The beds are closely folded and folds are overturned so that the beds all dip southeast, and the cleavage dip is 40° southeast. Similar conglomerates and interbedded thin blue limestones crop out in the valley east of Spring Plains and at the old Stoner quarry, north of Stoner Station. The character of these lower beds is shown in the following section measured in this quarry:

Section of Conestoga limestone in Stoner quarry north of Stoner Station

	Feet
Thick dark granular limestone and fine conglomerate	35±
Thin-bedded dark limestone containing much pyrite	2
Coarse conglomerate of white and dark granular marble and dark slabby limestone pebbles, flat and angular in shape, in dark argillaceous fine conglomerate matrix, merging into dark argillaceous limestone	15
Thin-bedded dark argillaceous micaceous limestone with shaly partings and pyrite cubes	3
Massive conglomerate of light-colored limestone pebbles, up to 2 feet in size, in dark fine conglomerate matrix	20
	75±

The conglomeratic beds are exposed also in the south quarry north of Wrightsville, at Susquehanna River, and the section of these exposed beds is given under Kinzers formation, on page 54.

In the belt of Conestoga limestone southwest of York the limestone is largely weathered to a deep soil full of small residual quartz fragments. The exposed rock is largely dark-blue impure limestone with some thin black slate and limestone conglomerate. In the valley around Hanover there are almost no outcrops of the formation and the only evidence of its presence in most places is thin residual fragments of black slate blotched white by weathering, and residual quartz in the yellow clay soil. However, thick beds of granular quartzose limestone and limestone conglomerate in a matrix full of round glassy quartz grains, which weathers to sand, are exposed in the Hershey sand quarry in the northern part of Hanover. (See Pl. 17.) The pebbles in the conglomerate are elongated parallel to the cleavage. These beds are similar to those near the base of the Conestoga formation quarried at Midway in Adams County, where the following section of these beds was measured:

Section of Conestoga limestone at school, North Midway, 2 miles west of Hanover

	Feet
Blue thin-bedded slaty argillaceous limestone containing scattered pebbles of sandy white marble and veined with calcite............	5+
Sandy limestone, weathering to porous rust-stained sandstone	10
Limestone conglomerate with pebbles of sandy limestone	5
Banded impure blue limestone	3
Dark limestone	5±
White marble with dark limestone pebbles; long pebbles of sandy limestone at base; local unconformity	6±
Thick-beds of sandy limestone containing round glassy quartz grains; weathers to porous crumbly, rust-stained sandstone (quarried for building sand)	20+
Thin-bedded impure blue limestones, poorly exposed and thickness not determinable.	
	54±

Unconformity at base.—The irregular distribution of the Conestoga limestone and its discordant relation to the underlying formations in the region clearly indicate that it is unconformable to these formations, but the general lack of clear contacts makes it difficult to determine the precise nature of the overlap. In general, the dip of the bedding of the Conestoga limestone accords with the dip of the underlying or adjacent formation, but in a few quarries a discordant relation is observed. In the old quarry north of the Lancaster water works (Pl. 18 A) a conglomerate composed of large blocks of white marble in a darker fine limestone conglomerate matrix at the base of the Conestoga is markedly unconformable on the underlying Lower Cambrian dolomite. South of this quarry limestone conglomerate fills deep channels and narrow crevices in the underlying limestone, some of which are 20 feet deep with nearly vertical walls. (See Pl. 18 B.)

West of the quarry in which the unconformity is exposed is a quarry operated by C. D. Stoner of Columbia.[46] The present opening on the north side of the quarry exposes thick-bedded ribbed blue limestone with thinner argillaceous beds in a gentle anticline. When this quarry was visited in preparation of the report on the Lancaster quadrangle the writers believed that these rhythmically banded earthy limestones belonged in the Conestoga formation because fossil shells

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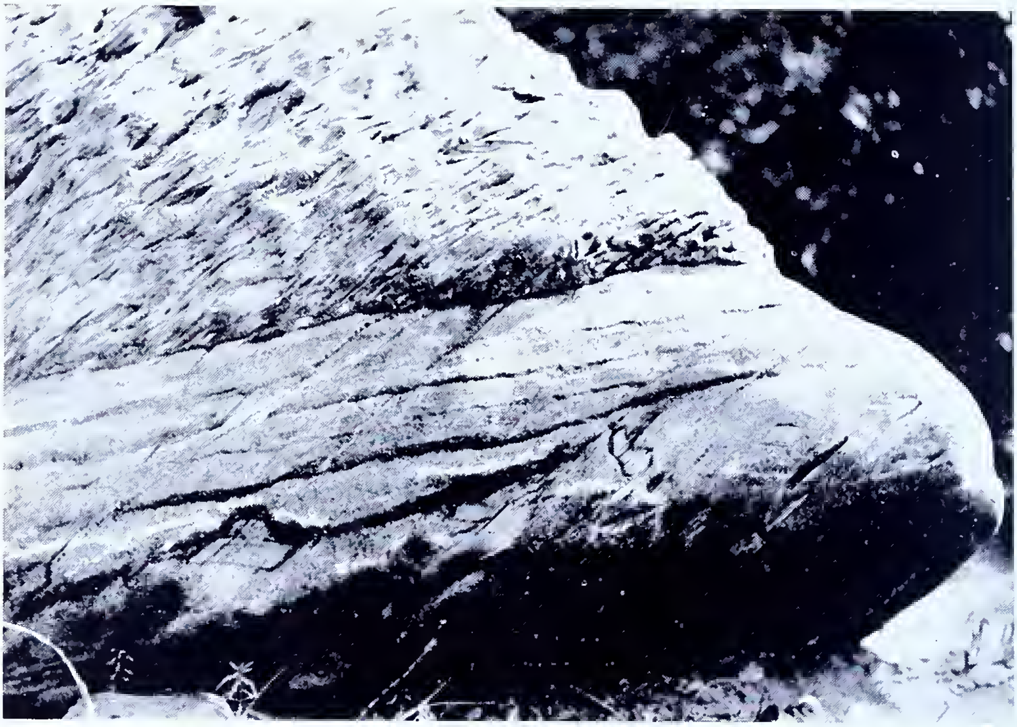
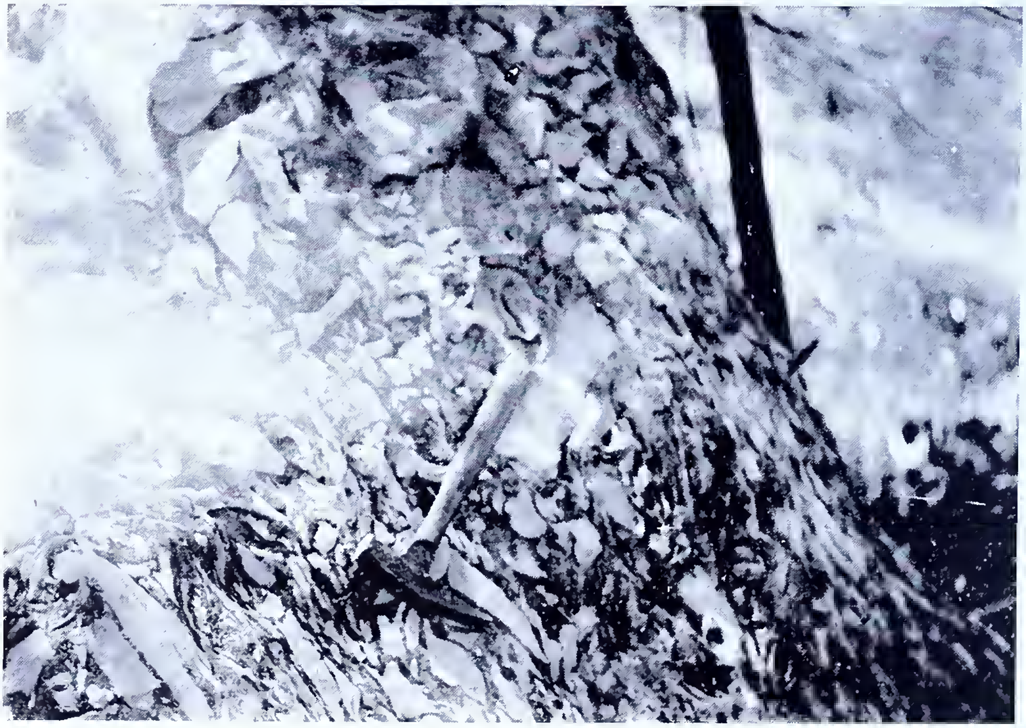
[46] Stose, G. W., and Jonas, A. I., op. cit. (Lancaster atlas), p. 75, 1930.



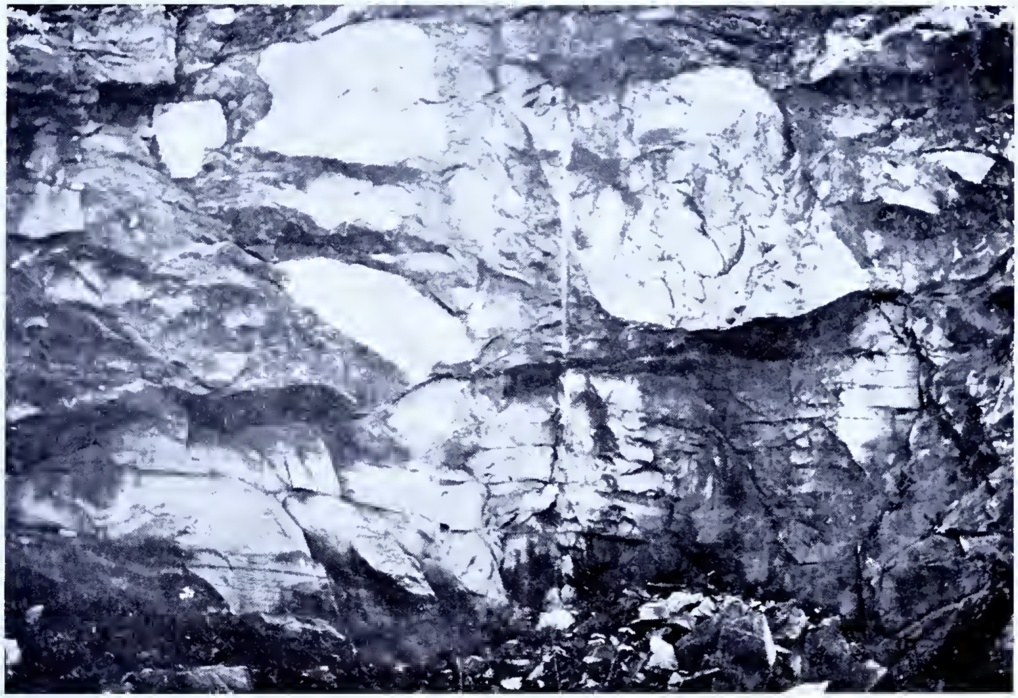
A. Siliceous beds in Conestoga limestone.

Very siliceous limestone and sheared limestone conglomerate, which weather to sand. Hershey sand pit in northern part of Hanover.

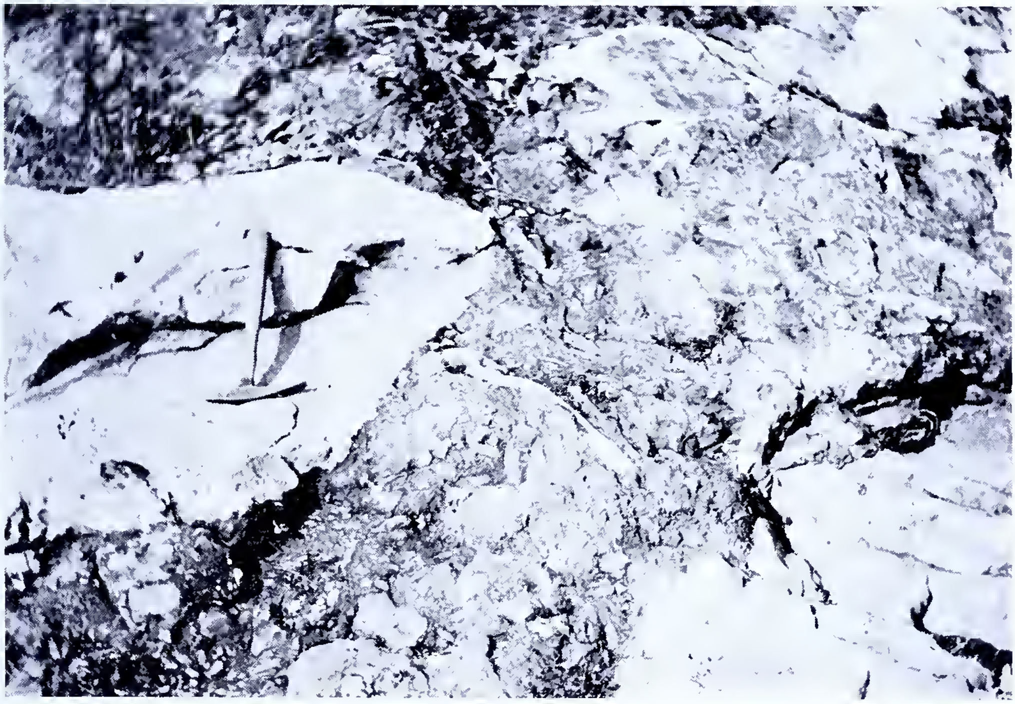


B. Conglomerate in Conestoga limestone.

Coarse conglomerate of angular limestone fragments in siliceous matrix, Hershey quarry.



A. Unconformity and basal boulder bed of Conestoga limestone.
Old quarry north of Lancaster water-works.



B. Channel in Ledger dolomite filled with conglomerate.
Conglomerate is part of the Conestoga limestone. Near Lancaster water-works.

found in similar beds in the same stratigraphic position east of York had been determined to be of probable Chazy age. Since this shell is now known to be *Nisusia festinata* (Billings)[47], of Lower Cambrian age, the banded blue limestone is known to be part of the Kinzers formation. In the south side of the quarry blue crystalline limestone and limestone conglomerate of the Conestoga is exposed dipping south, overlying the Kinzers formation in an unconformable or fault relation. The writers and others have found fossils of Lower Cambrian age in similar beds at this horizon north of Lancaster and westward in Lancaster County to Columbia, and in York County west of the river, and have revised the mapping of the Kinzers formation and the northern boundary of the Conestoga limestone in those areas. Similar fossiliferous argillaceous and sandy limestones, mapped as Conestoga in the Gettysburg area[48], Adams County, are now placed in the Kinzers formation, and a revision of the geology of that area is given in a figure in a forthcoming paper.

Age and correlation.—The fact that the Conestoga limestone is unconformable on the Ledger dolomite and older rocks of the region, overlapping in places onto the Antietam quartzite of Lower Cambrian age, indicates that its deposition followed a period of uplift and erosion and it is therefore considerably younger than these formations. In York County and in the western part of Lancaster County the youngest rock that it overlies is the Ledger dolomite. In Chester Valley, near Coatesville, the Conestoga limestone overlies Elbrook limestone, and west of Coatesville progressively overlaps the older formations down to the Antietam.[49]

No fossils have been found in the formation in York or Lancaster Counties. As previously stated, fossils collected by the writers in the quarry of the York Valley Lime & Stone Co., 6 miles east of York, were reported[50] to have come from the Conestoga limestone. They are now known to have come from the underlying Kinzers formation. Fossils collected from the base of the Conestoga limestone at Henderson Station, in the eastern part of Chester Valley south of Norristown, are the only determinable fossils known from this formation. These fossils are cephalopods and gastropods determined by E. O. Ulrich and A. F. Foerste to be of Beekmantown age.[51] The formation in Chester Valley is therefore of Lower Ordovician age. Whether the Conestoga limestone in the type locality in Lancaster Valley and westward in the Hanover-York area is of this age or somewhat older can be determined only by fossils obtained in that area. For the present the Conestoga limestone is classed as probably of Ordovician age.

The Conestoga limestone in the Hanover Valley is in strike with the limestones of the Frederick Valley, Maryland, 15 miles to the southwest. The intervening area is covered by Triassic rocks. The limestones of Frederick Valley comprise the Frederick limestone of Upper Cambrian age and the Lower Ordovician Grove limestone. These fossiliferous limestones lithologically resemble the Conestoga limestone, but the Conestoga limestone is more closely folded and in large part more metamorphosed. It is possible that the Conestoga limestone may be equivalent in part to both the Frederick and Grove limestones, and if so, is in part Upper Cambrian in age.

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[47] Stose, G. W., and Jonas, A. I., Age reclassification of the Frederick Valley (Maryland) limestones: Bull. Geol. Soc. Amer. vol. 27, p. 1671, 1936.

[48] Stose, G. W., op. cit. (Fairfield-Gettysburg folio). See geologic map, 1929.

[49] Stose, G. W., U. S. Geol. Survey, Geol. Atlas, Coatesville-West Chester folio (no. 223), geologic map, 1932.

[50] Stose, G. W., and Jonas, A. I., op. cit. (Middletown quadrangle), p. 35, 1933.

[51] Jonas, A. I., and Stose, G. W., op. cit. (Limestones of the Frederick Valley), pp. 1670-1673, 1936.

PALEOZOIC ROCKS NORTH OF THE TRIASSIC BASIN

The Paleozoic rocks in York County and the adjacent part of Cumberland County covered by the map in Plate 1 are Cambrian quartzites and Cambrian and Ordovician limestones and shales. These rocks differ somewhat from those south of the Triassic belt, and are divided into different formations, so that it is desirable to describe them under a separate heading. The Cambrian quartzites are exposed only in South Mountain, the larger part of which is in Cumberland County. The limestones and shales are almost wholly in Cumberland County. The formations to be described are given in the chart, page 34.

Cambrian system

LOUDOUN FORMATION

Distribution.—The Loudoun formation is the basal quartzose deposit of the Cambrian in South Mountain. It is softer than the overlying Weverton quartzite, and forms the slopes of ridges capped by that formation. It outcrops in a sinuous band about half a mile wide which extends northeastward up valleys between several hills of the quartzite which pitches northeast. The formation lies chiefly in Cumberland County, only the southeast end extending into York County, where it is terminated by the Triassic border fault. It is cut off also at the west by the Reading Banks thrust fault west of Rocky Ridge.

Character and thickness.—The Loudoun formation is a heterogeneous deposit of unassorted argillaceous and quartzose materials of gray, green, and purplish colors, which has been so compressed that it is crystallized to sericitic schist. It contains scattered unassorted pebbles of various sizes. It seldom outcrops because of its soft character and mantle of quartzite debris from the overlying Weverton. Most of its outcrops are soft purple arkosic sandstone. Its basal beds are composed largely of unassorted purplish residual fragments and fine regolith of the underlying pre-Cambrian rhyolitic and basaltic lavas and quartz. Its thickness in Cumberland County is estimated to be about 300 feet.

Correlation.—No fossils occur in the Loudoun formation. It conformably underlies fossiliferous rocks that contain Lower Cambrian fossils and is therefore regarded as of Lower Cambrian age. It underlies the Weverton quartzite, and these formations have been traced continuously southwestward along South Mountain to Weverton, Maryland and Loudoun County, Virginia, on the Potomac, the type localities of these formations. The Loudoun formation unconformably overlies the pre-Cambrian rhyolitic and basaltic lava flows.

WEVERTON QUARTZITE

Distribution.—The Weverton quartzite is a resistant rock which caps prominent ridges in this part of South Mountain. Synclines of the quartzite in Cumberland County southwest of Dillsburg make Rocky Ridge, Long Mountain, and The Peak, a small outlier at its southwest end. It also makes Stone Head, a small rocky knob in York County. The Weverton quartzite makes a very sinuous band about half a mile wide from Stone Head to the limestone lowland west of White Rocks. It is terminated at the southeast by the Triassic boundary fault south of Stone Head, and a branch of this fault on the east side of Stone Head cuts out most of the quartzite. The Weverton is abruptly terminated by the Reading Banks fault west of White Rocks.

Character and thickness.—The Weverton quartzite in this area is a thick-bedded hard quartzite with conglomerate beds. The basal beds are generally conglomeratic, and great slabby masses of this rock strew the slopes below it and conceal the underlying softer Loudoun formation. Much of the Weverton quartzite is feldspathic, with mica partings, and some of the beds are ferruginous, purple banded, and have current bedding. On Stone Head a basal conglomerate of 1-inch white quartz pebbles in coarse gray quartzite matrix is overlain by purple-banded sericitic quartzite with scattered smaller pebbles. The basal conglomerate on the hills northeast of Whiskey Spring has flattened rounded 3-inch quartz pebbles. The thickness of the formation is estimated to be about 500 feet.

Correlation.—The Weverton quartzite contains no fossils. It conformably underlies rocks that contain Lower Cambrian fossils and is therefore regarded as of Lower Cambrian age. The quartzite is continuous southwestward to the Potomac River at Weverton, Maryland, the type locality.

The Loudoun formation and Weverton quartzite are equivalent to the Chickies quartzite described in the area south of the Chickies overthrust.

MONTALTO QUARTZITE

Distribution.—The Montalto quartzite directly overlies the Weverton quartzite in this area. Harpers shale, which lies above the quartzite in the South Mountains of Franklin County, is absent here. The Montalto quartzite, which is a member of the Harpers in Franklin County, gradually expands northeastward and displaces the shale. The Montalto quartzite is a very hard vitreous pure quartzite that makes some of the highest and most rugged ridges in the area. It makes the top of the high anticlinal ridge northeast of Stone Head, and is cut off at the west by the Stone Head fault. It makes also the high top of Long Mountain and the crest of the ridge to the northeast, north of Dogwood Hollow. This ridge is the southeast limb of the plunging end of the South Mountain anticline, and the Montalto quartzite makes the high peak at the end of the mountain, 2 miles northwest of Dillsburg. The quartzite continues westward on the ridge that forms the north limb of the fold, to its abrupt end 1 mile southwest of Reading Banks, where it is cut off by the Reading Banks fault. It is offset about 2 miles by the fault, and the ridge continues southwestward toward Piney Mountain.

Character and thickness.—The Montalto quartzite is a hard, vitreous to coarse granular white quartzite, in part finely laminated and current bedded. It contains dark quartz grains and scattered feldspar grains in places. Many of the beds have *Scolithus* tubes that cross the bedding at right angles. It is distinguishable from the underlying Weverton by the absence of conglomerate beds, and feldspar grains where present are small and scattered. Softer and thinner-bedded quartzites that mark its top at the plunging end of the South Mountain anticline make a curving shallow valley between the hard quartzite ridge and that of the overlying Antietam quartzite south and east of White Rocks. In Franklin County, where the Montalto quartzite lies in the middle of the Harpers shale, it increases in thickness from about 100 feet at the south to 750 feet near the type locality, and to 1,000 feet farther north. In eastern Cumberland County it is estimated to be about 800-1,000 feet thick.

Correlation.—No fossils, except the filled worm boring of *Scolithus linearis,* have been found in the Montalto quartzite. It is conformably overlain by the Antietam quartzite which contains Lower Cambrian fossils and therefore is of Lower Cambrian age. It has been traced continuously southwestward to the type locality at Montalto, in Franklin County.

ANTIETAM QUARTZITE

Distribution.—The Antietam quartzite forms the outer ridges of South Mountain, adjacent to the limestone lowland. Northeast of Stone Head it outcrops on the north and south slopes of the anticlinal ridge which plunges under the Tomstown dolomite 1¾ miles southwest of Dillsburg. It is cut off at its west end by the Stone Head fault and on its south side by the Triassic boundary fault. North of the Stone Head fault it continues northwest of Dillsburg and makes a curving outer ridge nearly 1,200 feet in altitude at the plunging end of the South Mountain anticline, and continues on the north flank of the anticline southwestward to White Rocks. Here it again makes a curving ridge which projects into the limestone valley around another sharp plunging anticline. The Antietam quartzite is abruptly terminated just southwest of the Reading Banks by the Reading Banks thrust fault, where it is offset 2 miles southwestward, and continues in that direction as a low ridge or terrace on the north side of the Montalto quartzite ridge.

Character and thickness.—The Antietam quartzite is a vitreous to granular white quartzite containing many *Scolithus* tubes. Some beds, where fresh, have a bluish color. A fine conglomerate of round to oval quartz pebbles occurs in places. The upper beds are laminated by ferruginous partings that weather rust stained and contain fossils. Some interbedded shaly layers at the top of the formation at Mt. Holly Springs, west of this area, are also fossiliferous. In the vicinity of Mt. Holly Springs a white, sericitic, highly siliceous, residual clay occurs at the top of the formation and has been extensively mined for white clay.[52]. It is probably the leached product of a sericitic finely argillaceous quartzite or quartzose schist at the top of the Antietam.

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[52] Stose, G. W., White clay of South Mountain, Pa.: U. S. Geol. Survey Bull. 315, pp. 322-334, 1907.

Residual iron ore is also associated with these upper beds and has been extensively mined on the flanks of South Mountain. Residual iron ore at this horizon has been extensively mined at the Reading Banks in Cumberland County, at the foot of the north slope of South Mountain, on the north side of the valley of Dogwood Run in York County, and on the south slope of the Antietam quartzite ridge south of Dogwood Run. Much residual iron-ore float is still present in the mountain wash and soil along the contact of the Antietam quartzite and Tomstown dolomite in the area. At Mt. Holly Springs phosphorus, in the form of wavellite (aluminum phosphate), occurs as concretions with the iron ore, and was once prospected.[53]

The estimated thickness of the Antietam quartzite in this area is 500 feet.

Correlation.—Fossils were collected by Walcott[54] in the upper shaly beds of the Antietam quartzite at Mt. Holly Springs, Cumberland County, just west of the area here mapped. These fossils included fragments of *Olenellus* and *Hyolithes communis.* In the vicinity of Waynesboro, Franklin County, Walcott collected in addition *Camarella minor* from similar beds at the top of the formation. These fossils are of Lower Cambrian age. The formation is named from Antietam Creek in southern Maryland, on whose tributaries it is exposed. The formation has been traced from the type locality across Maryland and Pennsylvania to the South Mountain area in Cumberland and York counties.

TOMSTOWN DOLOMITE

Distribution.—The Tomstown dolomite directly overlies the Antietam quartzite and makes a curving band, about 1 mile wide, around the outcrop of the quartzite on the plunging end of the main South Mountain anticline in Cumberland County. It makes the lowland between the foot of the steep slope of South Mountain and a line of low hills composed of the overlying Waynesboro formation to the northeast. It is offset 1½ miles southward by the Reading Banks fault and makes a wide lowland west of this fault. The Tomstown dolomite is cut off 1 mile north of Dillsburg by the eastern part of the Dogwood Run fault, and is here offset southwestward. It is probable that the dolomite underlies much of the upper part of the valley of Dogwood Run, but the valley is deeply covered by mountain wash which largely conceals the bedrock. Its presence is indicated, however, by large ferruginous buff-colored chert along this part of the Dogwood Run fault, and by a small outcrop of dolomite at one place. The Tomstown dolomite in this area overlies the Antietam quartzite on the anticlinal ridge south of Dogwood Run.

At Saginaw, on Susquehanna River, south of the Triassic basin, an area of dolomite that overlies the Antietam quartzite is mapped as Tomstown because the Kinzers formation is not present in the section.

Character and thickness.—The general character of that Tomstown dolomite is not well shown in this area because exposures are very few.

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[53] Stose, G. W., Phosphorus ore at Mt. Holly Springs, Pa.: U. S. Geol. Survey Bull. 315, pp. 474-483, 1907.

[54] Walcott, C. D., Cambrian rocks of Pennsylvania: U. S. Geol. Survey Bull. 134, pp. 24-27, 1896.

The formation occupies a lowland which is heavily covered with quartzite wash from the adjacent mountains. From a general knowledge of the region to the southwest, especially in the Chambersburg quadrangle, it is known that the formation is composed largely of dark-gray dolomite. The lower part of the dolomite is knotty with impurities, whereas the uppermost layers are in part blue laminated limestone containing a small amount of black chert. In the Chambersburg area it was estimated to be 1,000 feet thick. In York County the upper part of the formation has recently been exposed in a large quarry 2 miles north of Dillsburg, near Williams Grove, close to the north edge of the county. The quarry face is about 100 feet high, and its curving face is about 700 feet long. The quarry is operated for road metal by Strayer and Lefever Bros. of Williams Grove. The beds dip 20°-45° SE, apparently at the plunging end of the South Mountain anticline. (See Pl. 15 B.) The beds exposed are as follows:

Section in Strayer & Lefever Bros. quarry

	Feet
Waynesboro formation	
Purplish thin-bedded limestone and interbedded shale above the quarry face	10+
Thin-bedded earthy dolomite with shaly partings and blue highly quartzose dolomite that weathers to buff porous sandstone	20±
Tomstown dolomite	
Thin-bedded to shaly dark dolomite	20±
Thick-bedded mottled to banded light-gray dolomite with some dark bands	60±

These beds are also exposed in small quarries to the south along the strike, as follows:

Section in J. H. Koller quarry

Thick-bedded sandy dolomite, weathered to porous buff earthy sandstone and chert (Waynesboro formation)	
Massive granular dolomite and laminated limestone	15
Dark, shaly dolomite, with some flint	4
Dark mottled even-grained dolomite	13
Light-gray fine-grained dolomite, in part laminated	15

Still farther south a small quarry exposes gray to buff banded earthy limestone and some coarse white marble, with a thin interbedded layer of red sandstone, varying from 2 feet to 4 inches. This limestone is directly overlain by diabase and is altered and colored reddish at the contact.

The total thickness of the Tomstown dolomite in this area can be estimated only roughly because of lack of exposures. It is estimated to be between 1,000 and 1,500 feet.

At Saginaw, south of the Triassic basin, Tomstown dolomite overlies the Antietam quartzite. Most of the dolomite exposed is dark-blue, siliceous, knotty banded of the Vintage type. The basal beds of white sericitic marble rest on slabby gray quartzite containing molds of the fossil shell *Obolus* at the top of the Antietam. Higher beds of coarse glistening dark and light mottled dolomite, in part rhymically banded, are of Ledger type. These dolomites are part of a larger area in Lancaster County, east of the river and in the reports on the Middletown, Lancaster, and New Holland quadrangles these dolomites were mapped respectively as Vintage and Ledger, although no Kinzers formation was present between them. They may be more properly classed as Tomstown dolomite, and are so mapped in this report. They lie north of the Chickies overthrust and belong to the Great Valley sequence in which fossiliferous beds are not found in the Tomstown.

Age and correlation.—No fossils have been found in the Tomstown dolomite in York County. The belt of the formation in York County continues southwestward in the Great Valley along the north foot of South Mountain to the type locality of the formation, Tomstown, Franklin County, in the vicinity of which *Salterella, Kutorgina,* and fragments of *Olenellus* have been collected from the formation, and the formation is therefore of Lower Cambrian age. The Tomstown dolomite is believed to be equivalent to the Ledger dolomite, Kinzers formation, and Vintage dolomite in the area south of the Triassic basin.

WAYNESBORO FORMATION

Distribution.—The Waynesboro formation overlies the Tomstown dolomite and makes an east-trending line of low hills about 1½ miles north of the foot of South Mountain in Cumberland County. At Williams Mill at the York County line the formation bends sharply south around the plunging end of the South Mountain anticline, and extends south into York County for about a mile, where it is cut off by the Triassic boundary fault. At the west the formation is offset 1½ miles southwestward by the Reading Banks fault, beyond which it continues to make a line of low hills that trend westward.

Character and thickness.—The Waynesboro formation is poorly exposed in York County and the few outcrops consist chiefly of earthy thin-bedded limestone with thin shales and very quartzose dolomite which weathers to sandstone and chert. The basal beds exposed at the top of the Strayer & Lefever Bros. quarry (Pl. 15 B) are quartzose dolomite and purplish shale and limestone. In Cumberland County it is composed largely of hard purple slaty shale and sandstone, or quartzose limestone, and has an estimated thickness of 750 feet. It is here very similar in character to the Waynesboro formation in the type locality in Franklin County, where the thickness is estimated to be 1,000 feet or more, and the sequence of beds is as follows:

Mottled slabby current-bedded sandstone and interbedded hard dark-purple siliceous ripple-marked shales.
Dark-blue limestone, dolomite, and fine-grained white marble, siliceous at the top.
Very siliceous gray limestone weathering to slabby porous sandstone and residual large round rough-surfaced chert and crystalline white quartz.

Age and correlation.—The Waynesboro formation in York County is traceable southeastward on the southeast side of the Great Valley to the type locality at Waynesboro, Franklin County. The only fossil obtained from this formation in the type area was a shell, referred to *Obolus (Lingulella)* sp. undet. and none have been found in Cumberland and York Counties. The formation is correlated in a general way with the Rome formation of the Southern Appalachians, which is also characterized by red sandy and argillaceous sediments, but the exact equivalence has not been established. The Rome contains a trilobite fauna referred to the Lower Cambrian by Resser[55], and therefore the Waynesboro formation is also classed as Lower Cambrian. The Waynesboro formation overlies the Tomstown dolomite in the Great Valley and is not represented above the Ledger dolomite in the area southeast of the Triassic sedimentary rocks where the Kinzers formation occurs between the Vintage and Ledger dolomites.

ELBROOK LIMESTONE

Distribution.—The Elbrook limestone, which overlies the Waynesboro formation, makes a broad belt of level land north of the low hills of the Waynesboro formation in Cumberland County. The belt is about a mile wide north of Williams Grove. To the east it curves southward around the plunging end of the South Mountain anticline, and then trends south to where it terminates against the Triassic boundary fault, west of Rosegarden, York County. A very narrow area is apparently present in York County adjacent to the fault east of Rosegarden, and an isolated area of similar rock is mapped as Elbrook in the vicinity of Beavertown. West of the Reading Banks fault, in Cumberland County, the area of the formation expands to over 2 miles in width.

Character and thickness.—The Elbrook limestone in Cumberland County is a thinly laminated to shaly well-bedded earthy limestone, white to pink marble, and dolomite. Where fresh, it has a light-blue color, but it weathers readily to buff color, with a whitish coating on the surface, and to buff slabby fragments of earthy tripoli. It makes a light porous earthy soil of high fertility. Similar earthy limestone, somewhat altered and mineralized by the adjacent diabase, is exposed along the Reading Railroad east of Rosegarden. The area of limestone in the fault block 1 mile west of Dillsburg, which is mapped as Elbrook, has the same characteristic lithology, but its stratigraphic relation to other Paleozoic formations is not exposed because it is overlain uncomformably by Triassic redbeds on the north side and faulted on the south side. The thickness of the formation north of Williams Grove, Cumberland County, is estimated to be about 1,600 feet. In the type locality in Franklin County it was estimated to be 3,000 feet thick, and there has a middle member of thick massive-bedded dolomite and quartzose limestone.

Age and correlation.—No fossils have been found in the Elbrook limestone in this area. The formation is continuous southwestward along the Great Valley to the type locality in Franklin County, where fragments of trilobites resembling *Ptycoparia* were collected. In central Pennsylvania other fossils of Middle Cambrian age have been found in the formation. In Virginia trilobites of the genera *Dolichometopus* and *Zacanthoides* of Middle Cambrian age occur in the Rutledge limestone, the equivalent of the lower part of the Elbrook. The formation therefore is considered to be of Middle Cambrian age.

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[55] Resser, Chas. E., Preliminary generalized Cambrian time scale: Geol. Soc. Amer. Bull. 44, p. 748, 1933.

CONOCOCHEAGUE LIMESTONE

Distribution.—The Conococheague limestone does not occur in York County, but is present in the part of Cumberland County covered by the geologic map in this report. It outcrops in a belt about 1 mile wide from Craighead northeastward to Churchtown, where it is broken by the Reading Bank fault and offset to the northeast. It continues eastward to a point 1½ miles northeast of Williams Mill, where it is overlapped and concealed by the unconformable and much younger Martinsburg shale which forms the shale hill at Shepherdstown.

Character and thickness.—The Conococheague is composed of variable limestones and dolomite. Alternate dark and light-colored beds, banded by very sandy limestone that weathers to slabby porous sandstone, characterize the formation. Certain light-blue pure limestones and white marble, which are reefs of *Crytozoons,* are conspicuous in places and have been quarried for lime. The sandy beds and accompanying residual chert make low ridges. No continuous exposures across the formation are available for the measurement of a cross section, and as the beds are closely folded and repeated, the thickness of the formation can be determined only roughly. It is estimated to be about 1,000 feet thick. In the type locality on Conococheague Creek, Franklin County, it is about 1,600 feet thick.

Correlation.—The formation contains reefs of *Cryptozoons* similar to those found in the Hoyt limestone of Upper Cambrian age near Saratoga Spring, N. Y. In the type locality in Franklin County two species of the trilobite *Dikelocephalus* and a shell, *Billingsella* sp., also of Upper Cambrian age, were collected from the formation.

Ordovician system

BEEKMANTOWN LIMESTONE

Distribution.—A small area of the Beekmantown limestone is present in the northern part of York County, but it is widespread in the part of Cumberland County included in the geologic map in this report. It outcrops in a wide area north of the Conococheague limestone from Salem Church to Mechanicsburg and eastward to New Cumberland at Susquehanna River. The basal member is overlapped by the Martinsburg shale west of Shepherdstown, but it is exposed around an elongated anticlinal area of Conococheague limestone southwest of Shiremanstown. The Beekmantown limestone is also exposed south of the hills of Martinsburg shale east of Shepherdstown between it and the Triassic boundary fault. Here an irregular area about half a mile wide is crossed by Yellow Breeches Creek and part of the area is in York County.

Character and thickness.—The Beekmantown limestone is a well-bedded light-blue pure limestone and light-gray laminated fine-grained magnesian limestone. Beds of dark glistening dolomite present in the formation are less regularly bedded and have a wavy upper surface, the waves having an amplitude of 3 feet or more. These structures are well shown in old quarries along the river south of Lemoyne. Some of the dolomite is lenticular and is gashed by irregular white calcite veins. Small black cherts are scattered through the limestone and occur as residual fragments of rust-coated chert in the soil. At the base of the formation there are beds of sandy-banded limestone, similar to that in the underlying Conococheague limestone, and associated quartzose edgewise conglomerate composed of angular slabby limestone fragments inclined at various angles and inclosed in a siliceous lime silt. Some of the less-pure layers weather to a siliceous network that stands in relief as bands on the weathered surface. These basal beds are named the Stonehenge limestone member, and have been separately mapped.

The limestone mapped as Beekmantown south of the Shepherdstown belt of shale hills does not have the distinctive characters of the Beekmantown limestone. It has more thick beds of dolomite and some white marble, and in most places is highly sheared to a platy rock. It is mapped as Beekmantown largely because of its stratigraphy position.

The formation is closely folded and the exposures are too infrequent to determine the sequence of beds and its thickness. In the vicinity of Chambersburg, Franklin County, the thickness of the formation is over 2,200 feet. It is probably between 1,500 and 2,500 feet thick in the vicinity of Shiremanstown.

Correlation.—Few fossils have been collected in the Beekmantown limestone of this area. The weathered surface of the purer beds of limestone in many places shows the presence of fragments of shells, most of which are sections of the coiled shells of gastropods. The most common forms that have been identified are *Ophileta, Eccyliopterus,* and *Maclurea.* These and other fossils of Beekmantown age have been collected from this formation in other parts of the State, and the formation is therefore correlated with the Beekmantown limestone of New York. Some of the limestone beds have crinkled minutely laminated layers that resemble simple forms of *Cryptozoon,* and were probably deposited by algae or other similar marine organisms. The basal member is similar in character to the Stonehenge member of the formation at Stonehenge, Franklin County, where it also contains fossils of Beekmantown age.

LEESPORT LIMESTONE

Distribution.—A narrow band, about ¼ mile wide, of Leesport limestone borders the south side of the shale hills northeast of Shepherdstown. It extends from Bowmansdale eastward to the river, but east of Shepherdstown it is offset nearly a mile by a north-south normal fault. On the north side of this belt of Martinsburg shale only one small area of the Leesport limestone was observed, southwest of Eberlys Mill.

Character and thickness.—The Leesport in this area is a shaly to thin platy argillaceous limestone. It is generally dark where fresh, but weathers readily to light-gray or light-buff platy fragments. It is recognized not only by its hard platy character and whitish weathered fragments, but by minute pieces of fossil shells and specks of black coal-like carbonaceous material which weather in relief and give its bedding planes a characteristic rough surface. Crinoid stem segments are the chief fossil forms identifiable. The fact that the Leesport was observed at only one place on the north side of the Martinsburg shale in this area, and is similarly sporadic in its occurrence east of the river in Dauphin County, may be due in part to its being squeezed out, or the adjacent shale being squeezed over it, in the intense compressing of this syncline of Martinsburg shale, but it may also be due to irregularity of deposition of the Leesport. It is known, as will be explained below, that the Martinsburg shale in this belt of the formation is unconformable on older rocks and some of these older formations are absent, and it is quite probable that the Leesport limestone when deposited was not as widespread as the overlying Martinsburg shale, and is also overlapped by it in places.

The formation is well exposed in many old quarries in the vicinity of Bowmansdale. The typical rock is thin-bedded to shaly, dark and light banded to black, hard compact slaty argillaceous limestone. The beds are so highly contorted, sheared, and slickensided that bedding cannot be determined. The schistose planes dip 20° S., and the rocks are apparently overturned, for they are overlain in the main quarry by well-bedded south-dipping blue limestone and thick lenticular dolomite. The formation is not well enough exposed in the area to determine its thickness, but its probable thickness and character of beds in undisturbed relations is suggested by the following section of the formation northwest of Lebanon, Lebanon County.

Section of Leesport limestone, in cut of Reading Railway northwest of Lebanon

	Feet
Dark fissile shale (Martinsburg)	
Thin-bedded, light-gray limestone with wavy hard slaty partings, weathering to a ribbed rock	30
Thick-bedded blue limestone, full of round glassy quartz grains, weathering to porous sandstone	6
Thin-bedded, fine-grained limestone with hard slaty partings ½ to 1 inch apart, weathering to a ribbed rock, and thin interbedded shale	45
	81

Correlation.—Few fossils have been collected from the formation here mapped as Leesport. On Yellow Breeches Creek, 1 mile south of Eberlys Mill, crinoid plates were collected from these slaty beds. Across the Susquehanna River in Dauphin County, in the southern part of Steelton, E. T. Wherry got a bryozoan, a cephalopod, and crinoid segments from limestone near the shale contact. Three miles east of Steelton, a bryozoan *(Eridotrypa)*, a brachiopod *(Dalmanella)*, and small crinoid stem segments, collected by the writers, were regarded by E. O. Ulrich as lower Trenton. The formation has the same stratigraphic position and is believed to be the same as thin-bedded to slaty argillaceous limestone that underlies the Martinsburg shale east of Harrisburg and which has been traced eastward to Leesport on the Schuylkill River, north of Reading. In much of this area it overlies very pure limestone of Stones River type which at Paxtang, 2½ miles east of Harrisburg, contains *Leperditia*, *Girvanella*, a large *Maclurea*-like gastropod, and other fossils of probable Stones River age.

Since the Leesport limestone directly underlies the Martinsburg shale and overlies the Stones River limestone, it occupies the same stratigraphic position as the Chambersburg limestone west of the river, but the Chambersburg limestone is a highly fossiliferous crystalline formation of post-Lowville (Black River) age, 750 feet thick in its greatest development near its type locality in Franklin County. The lithologic character, fossil content, and variable thickness of the slaty argillaceous (Leesport) limestone are so strikingly different from those of the Chambersburg that it is evident it was deposited under different conditions, and its meager fauna relates it with the basal limy beds of the Martinsburg shale to the west. It was named Leesport limestone[56] from its exposures on the Schuylkill River at Leesport. It is unfortunate, as stated by Miller,[57] that Leesport was selected as the type locality for the formation because the section of the rocks and their structural relations at Leesport are not clear. However, the thin-bedded limestone, which makes up the large part of the exposure, is typical of the formation to the west, and, as correctly stated by Miller, is similar to the cement rock to the east. The position in the section of a massive bed, 10 feet thick, of highly quartzose limestone, is not clear because of folding and minor faulting, but the undisturbed section of beds in the railroad cut northwest of Lebanon, quoted above, establishes its position in the middle of the thin-bedded limestone. If the section at Lebanon is taken as the type section, showing the sequence and thickness of the beds, and Leesport as the type locality where all the beds are present, no confusion need arise.

MARTINSBURG SHALE

Distribution.—The Martinsburg shale makes high hills in the vicinity of Shepherdstown, Cumberland County, and eastward to the Susquehanna River at New Cumberland. These shale hills extend southward to the York County line west of Grantham, where the shale is terminated by the Triassic boundary fault. The shale belt has a maximum width of 2 miles in the vicinity of Shepherdstown, but is only about half a mile wide to the eastward.

Character and thickness.—The formation is prevailingly a dark-gray fissile shale that weathers buff. It is closely folded and sheared in the Shepherdstown synclinal belt, and is injected by many quartz veinlets, so that the weathered outcrop consists of rust-stained fragments of shale and residual quartz. Beds of greenish to buff arkosic sandstone are interbedded in the shale, but their position in the section cannot be determined in this area. East of the Susquehanna River, in Dauphin County, similar arkosic sandstone and associated purplish red and hard green shale form the base of the formation. They are exposed only on the north margin of the syncline, northeast of Churchville. Their apparent absence elsewhere is probably in part due to crushing and squeezing out of beds in the intense compression of the syncline, especially on its southern border. The purple and green slates have ill-defined spherical structures resembling flattened amygdules and are believed to be tuffaceous beds. They increase in thickness eastward and are believed to be tuffaceous deposits associated with lava flows at the base of the Martinsburg at Jonestown, Lebanon County.[58] Here a basalt lava flow, about 300 feet thick, lies beneath the shale and rests on Beekmantown limestone and encloses fragments of the limestone in its lower part. A thick white quartzite present near the base of the formation at Jonestown may be a purer quartzose phase of the arkosic sandstone associated with the purple and green shales in the Shepherdstown area.

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[56] Stose, G. W., and Jonas, A. I., Ordovician shale and associated lava in southeastern Pennsylvania: Geol. Soc. Amer. Bull. vol. 38, pp. 509-511, 1927.

[57] Miller, Ralph, Stratigraphy of the Jacksonburg limestone; Geol. Soc. Amer. Bull., vol. 48, pp. 1710-1711, 1937.

The Martinsburg shale in the Chambersburg area is estimated to be 2,000 feet thick, but only the lower part of the formation, probably not over 500 feet, is present in York County and adjacent area.

Correlation.—Only a few indeterminable graptolites have been collected in this belt of Martinsburg shale by Bissell and Stose. Other better preserved graptolites were collected by the writers and others in arkosic sandstone at the base of the formation at Steelton, east of the river, but these also were indeterminable. In a calcareous sandstone near the base of the formation on Conodoguinet Creek northwest of Shiremanstown the following fossils collected by the writers were identified by Ulrich: *Premitia bivertex, Primitella* cf. *P. ulrichi* and *P. unicornis*, *Dalmanella* (sm. sp.), *Leptobolus* cf. *L. lepis, Ctenobolbina* sp., and were referred by him to the upper Trenton. The Martinsburg shale in the Shepherdstown syncline, therefore, is probably of upper Trenton and later age.

In the Chambersburg area *Cryptolithus* sp. and *Sinuites* sp. occur in thin limestones interbedded with shale at the base of the Martinsburg. These fossils are regarded by Ulrich as of lower Trenton age, and may be equivalent to the Leesport in Cumberland, York, and Dauphin counties.

It is of interest to note that on the west side of the Susquehanna, 5 miles north of Harrisburg, two graptolite faunas were collected within the main shale area which are referred by Ulrich respectively to the Normanskill and the Deepkill. Ulrich identified 7 diagnostic species of Normanskill graptolites and 12 diagnostic Deepkill species. If these faunas are correctly identified, this part of the shale is older than Trenton and is not properly part of the Martinsburg as defined. It is questioned whether these two unusual graptolite faunas may possibly be recurrent faunas closely resembling the older Deepkill and Normanskill faunas but of later, possibly Trenton age, but Ulrich does not think this tenable.

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[58] Stose, G. W., and Jonas, A. I., Geol. Soc. Amer. Bull., vol. 38, pp. 530-532, 1927.

The belt of shale near Shepherdstown joins the main body of shale of the Great Valley at Hummelstown (see fig. 4), which is continuous southwestward across Pennsylvania and Maryland to the type locality at Martinsburg, W. Va. In the Chambersburg area, where the Martinsburg shale is about 2,000 feet thick, Eden fossils occur in its upper part, but these upper beds are probably not present in the Shepherdstown syncline.

RELATIONS OF THE MARTINSBURG SHALE TO THE UNDERLYING LIMESTONES

The Martinsburg shale, which, in the Chambersburg area, conformably overlies the Chambersburg limestone, of Black River age, and Stones River limestone, of Chazy age, gradually transgresses these formations toward the east and southeast and rests on Beekmantown and older limestones in the southern belts of the formation, including the Shepherdstown syncline near Susquehanna River. The Chambersburg limestone is much thinner near Susquehanna River than in the type area near Chambersburg, and apparently two faunal zones are absent, but as these are in the lower part of the formation, this thinning is not due to the unconformity at the top. At the west bank of Susquehanna River the Chambersburg limestone is reduced in thickness to about 135 feet, but the beds are here overturned and greatly crushed, slickensided, and veined with calcite, so that this thinning is probably in part due to squeezing out of beds and local faulting on the south limb of the broad syncline. East of the river the Chambersburg has not been recognized and is probably absent.

The Stones River limestone, which underlies the Chambersburg, is well represented west of the river, but is much thinner than in the Chambersburg area. Just east of the river the pure limestone of the Stones River is apparently very irregular in outcrop and thickness. The contact here is generally vertical, or steeply overturned to the south, and the beds at the contact in places are slickensided and show other evidence of intense compression and differential movement, so that squeezing out of beds and local faulting may account for some of the irregularity and thinness of the Stones River. Farther east the Stones River again is uniformly a thick pure fine-grained marble which is extensively quarried for high-calcium limestone.

The basal 20 to 100 feet of the Martinsburg shale in the Chambersburg area has thin limestone beds interbedded in the shale, which contain fossils of Trenton age. The lower 100 feet or more of the shale in the main belt northwest of Shiremanstown also contain thin argillaceous limestones some of which contain fossils of Trenton age. These argillaceous limestones are seldom exposed because they weather readily, but an associated peculiar arkosic sandstone bed, seen only in weathered outcrops where it is porous and rusty and mica-spangled, and is therefore probably calcareous when fresh, is present nearly everywhere in this area and is believed to represent a bed of this limestone. East of the Susquehanna River thin blue limestone beds beneath the shale increase in thickness and prominence eastward and are named Leesport limestone.

Other marked changes in the composition of the shale also take place in this eastern part of the area. Much of the shale in the lower part of the formation is red and contains many coarse arkosic sandstone beds. In the vicinity of Jonestown, 5 miles northwest of Lebanon, a basalt lava flow underlies the red shale, and when the lava was erupted it flowed out on the limestone floor and engulfed fragments of the limestone and altered them into hard siliceous rock.[58] The underlying limestone is apparently the Beekmantown, and no limestones of the Stones River, Chambersburg, or Leesport types are present beneath the lava. Similar red shale and associated green shale occur near the base of the Martinsburg to the west and these extend into the Shepherdstown-Steelton syncline east of the river. (See fig. 4.)

It is evident therefore that physical conditions during Trenton time were markedly different in the east than they were in the west, which resulted in a change of character of sediments that may be summed up as follows:

The basal beds of the Martinsburg shale, which are of Trenton age, gradually become more limy eastward and culminate in a thick deposit of argillaceous limestone or cement rock (Leesport limestone) ; a lava flow occurs locally at the base of the formation in the east; red and green shale, in part of tuffaceous origin, and arkosic sandstone appear at the base of the shale toward the east; and unconformity at the base of the shale is indicated by the absence of the Chambersburg limestone east of Susquehanna River and the absence locally of the Stones River limestone.

Similar changes in sedimentation may be observed by one passing southward from the main shale belt in the Great Valley. In the Shepherdstown-Steelton syncline thin argillaceous limestone of Trenton age is locally distinguishable beneath the shale, and is recognized as Leesport limestone. East of Steelton a thin band of purplish-red shale and green shale of a peculiar type, believed to be of tuffaceous origin, lies near the base of the formation, and similar beds occur near the base throughout the other synclinal areas of shale to the south, nearly to Lancaster, a distance of 20 miles across the strike. These tuffaceous beds are believed to be related to the basalt flow at Jonestown. The Chambersburg and Stones River limestones are everywhere absent adjacent to these southern shale areas.

At the southwest end of the Shepherdstown syncline the Martinsburg shale is markedly unconformable on the underlying limestones. Here all the formations down to the Elbrook limestone are overlapped by the shale, and they were apparently uplifted on the plunging northeast end of the South Mountain anticline and bevelled off by erosion before the shale was deposited.

ROCKS OF THE MARTIC OVERTHRUST BLOCK

General description.—The Martic overthrust block lies southeast of the known Paleozoic rocks of the East Prospect and Jefferson synclines and the Holtz anticline. The rocks of the Martic overthrust block are

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[58] Stose, G. W., and Jonas, A. I., Geol. Soc. Amer. Bull., vol. 38, pp. 530-532, 1927.

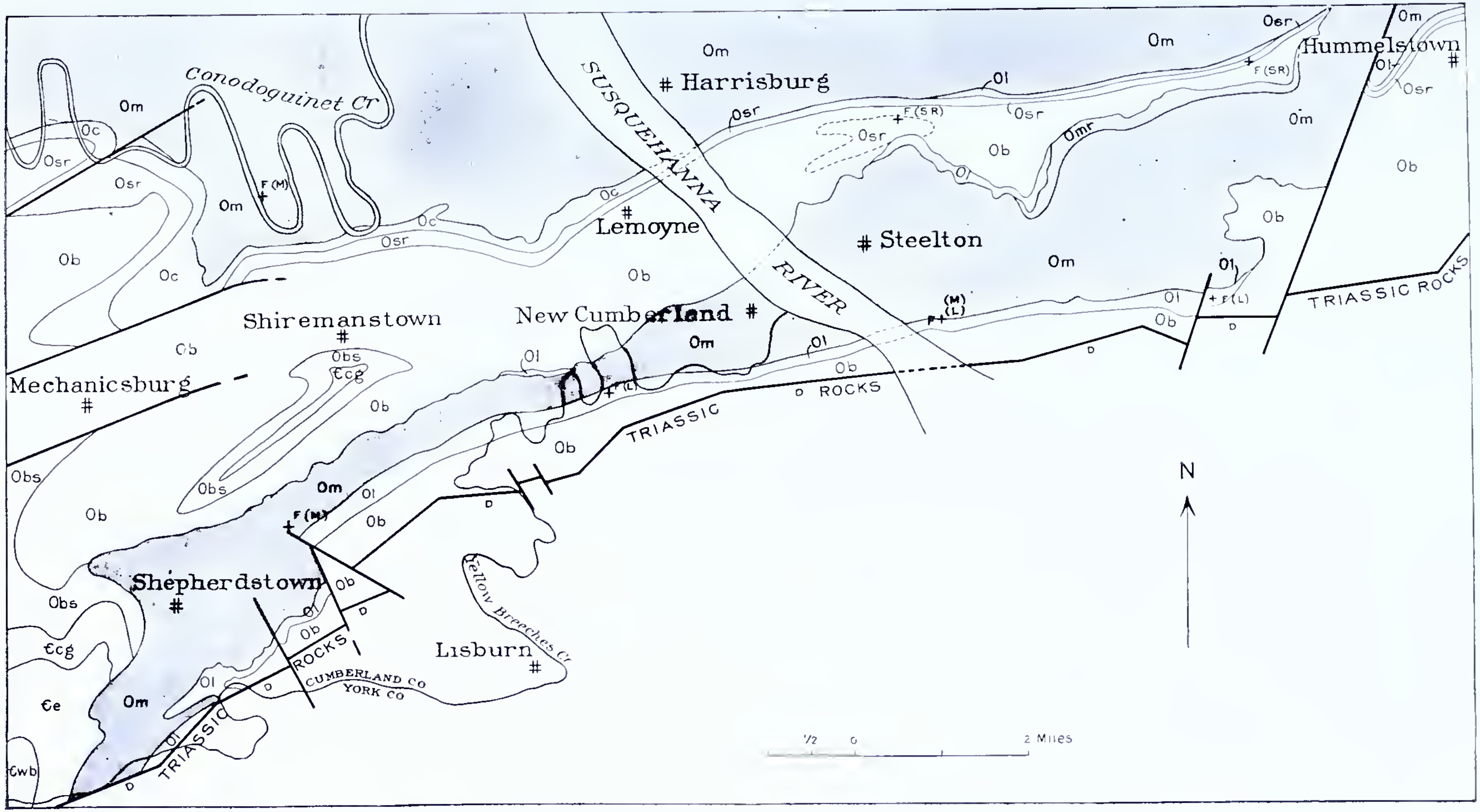

Figure 4. Sketch geologic map, showing unconformable relation of Martinsburg shale to older formation in northern York County and parts of adjacent counties. Om, Martinsburg shale; Omr, Red shale at base; Ol, Leesport limestone; Oc, Chambersburg limestone; Osr, Stones River limestone; Ob, Beekmantown limestone; Obs, Stonehenger member; Ɛcg, Conococheague limestone; Ɛe, Elbrook limestone; Ɛwb, Waynesboro formation; D. Downthrust side of fault; F. Fossil locality; M. Martinsburg; L. Leesport; SR. Stones River.

crystalline schists, largely argillaceous and arenaceous in character, which in York County include mica schist, quartzite, marble associated with volcanic flows and tuffs belonging to the Glenarm series, and infolded conglomerate and slate.

The albite-chlorite schist facies of the Wissahickon formation and the Peters Creek quartzite, comprising quartzite and mica schist, occupy the southeastern part of York County. In the northwestern part of the area of the Wissahickon formation, infolded metabasalt extends from a point half a mile north of Bridgeville, on the Susquehanna, southwestward across the county and passes into Maryland. Wakefield marble occurs in the volcanic belt near the Maryland line. The Marburg schist, with infolds of associated quartzite in the Yoe and Wentz synclines, lies northwest of the albite-chlorite schist of the Wissahickon formation. The Cardiff conglomerate and Peach Bottom slate are infolded in the Peters Creek quartzite in the southeastern part of the county. Serpentine intrudes the Peters Creek quartzite in York County at Delta and to the northeastward.

Structural explanation.—Before describing the formations that make up the Martic overthrust block a general discussion of their structural peculiarities will be given. It is largely because of the structure of these rocks that beds cannot be traced far, especially in the Wissahickon formation and Peters Creek quartzite; that thickness of the formation cannot be measured; and no accurate sequence of these rocks can be determined. All the formations of the Martic overthrust block are closely folded. The Wissahickon formation, the Peters Creek quartzite, and the Marburg schist are made up of an alternation of thinly laminated micaceous and quartzose layers, with some thicker layers of quartzite. In the mica schists the quartzose layers are for the most part discontinuous and form elongated lenticles completely surrounded by a micaceous envelope. Since the mica bends around the quartzose layers and these harder layers pinch and swell, the surface of the layers is a gentle roll that simulates open folding. (See Pl. 30 A.) This is especially true near the Tucquan anticline (see Pl. 30, C) where the dips of the layering are low. The Tucquan anticline here lies in the Wissahickon formation and extends southwestward across York County. It enters York County 3 miles east of Airville, on the Susquehanna west of Tucquan, Lancaster County, and its axis passes southwestward through Muddy Creek Forks and extends to the Maryland line in a direction nearly parallel to South Fork of Muddy Creek. At the crest of the anticline the dip of the layers is horizontal. The southeast dip gradually steepens to 45° at the southeastern border of the Wissahickon formation, a distance of 8 miles. Farther southeastward in the Peters Creek quartzite, the dip steepens to 70° or 75° at the northwest side of the Cardiff conglomerate, which, with the Peach Bottom slate, is closely folded in the Peach Bottom syncline. Southeast of the center of the syncline the dips are to the northwest.

Northwest of the crest of the Tucquan anticline the dip of the layers is northwest and steepens to 70° northwest of Springvale. This layering is the prominent structure in the schists, but they show also closely appressed recumbent folds whose axial planes are parallel to the dips of the layers. These recumbent folds are best preserved in the quartzite layers which, south of Felton, have an amplitude of 4 feet. Recumbent folds of smaller dimensions are visible in the mica schists (see Pl. 30, B) and metabasalt, especially in the good exposures along Codorus and Muddy Creeks and near Susquehanna River. Even where recumbent folds are not visible to the unaided eye they can be seen generally in thin section as minute folds. It is evident therefore, that the structure of these rocks is not that of open folding even near the Tucquan arch where the most prominent structure is that of low-dipping layers. The rocks have suffered intense and close folding, but these folds have been in large part sheared out, and in many outcrops their crests are no longer seen. The resultant structure is one of wavy discontinuous layers with mica partings which pinch and swell around the discontinuous residual lenses of the harder constituents. This layered structure will be called foliation in this report. Foliation therefore is here used to denote a mechanical differentiation of the original beds into more or less irregular layers, the layering being the result of slip in closely appressed and drawn out folds so that the crests of the individual folds are more or less completely destroyed. Such a foliation lying parallel to transposed *s*-planes has been called by E. B. Knopf,[59] "transposition cleavage," in contrast to "slaty cleavage" or transverse cleavage, which cuts across the original *s*-planes. The term *s*-plane means any layering or plane of discontinuity possessed by the rock before folding, whether it was stratification, schistosity or shear planes. If the original layering that was folded into recumbent folds was bedding, the foliation in the rocks of the Glenarm series is also largely parallel to the bedding planes, but, because the original position of the layering has undergone a complete transposition, the present superposition of the foliation layers is not a stratigraphic succession.

To add to the complexity of the structure, there has been an arching of the foliation into the Tucquan anticline and a crumpling of the foliation layers into fine crinkles and a development of steep transverse cleavage that cuts across the foliation layers. The Peach Bottom slate, which together with the Cardiff conglomerate overlies the Glenarm series, appears to show closely folded bedding cut by steep transverse cleavage.

Pre-Cambrian (?) rocks

WAKEFIELD MARBLE

Distribution.—The Wakefield marble is apparently the oldest formation exposed in the area. It occurs in the south-central part of York County in a narrow valley in the albite-chlorite schist of the Wissahickon formation and extends southwest from Hokes Postoffice to Blackrock at the Maryland State line. At the State line, south of Blackrock, and at a point 1 mile east of Lineboro other narrow valleys contain marble just over the line in Maryland. Southwestward in

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[59] Knopf, E. B., Retrogressive metamorphism and phyltonitization: Amer. Jour. Sci., vol. 2, pp. 16-18, 1931.

Maryland the Wakefield marble extends across Carroll[60] and Frederick Counties, where it is infolded with volcanic rocks.

Wakefield marble occurs also within the albite-chlorite schist in a small valley 1½ miles south of Chanceford. It is exposed in a small quarry southeast of a road crossing Toms Creek, and probably underlies the flat lowland north of the road where no exposures are seen.

In the valley east of Zumbrum School 2 miles south of Marburg white, impure marble is exposed in an old quarry east of the road along the valley. The marble occurs in Marburg schist and along a fault that offsets areas of the quartzite associated with the schist. Twelve miles to the northeast in strike with this marble area, blue crystalline limestone occurs in a valley which extends from a point ¾ mile east of Loganville, northeast to East Branch of Codorus Creek. The limestone outcrops in several old quarries on the northwest side of the valley. At both ends of the area are limonite pits, now abandoned and filled with water. The limestone is surrounded by Marburg schist, both formations are closely folded, and at the southwest end a narrow infold of Marburg schist extends into the limestone.

Character.—The Wakefield marble has not been found in fresh exposures in southern York County, but is everywhere weathered to a blue clay. In Carroll County, Maryland, the marble of this belt is a crystalline bluish-gray to white marble made up of coarsely crystalline calcite with some finer grains of calcite, quartz, and muscovite. When the metabasalt is absent between the marble and the albite-chlorite schist facies of the Wissahickon, the marble grades upward into the Wissahickon schist through a calcareous schist containing bands of muscovite, chlorite, albite, quartz, and calcite. The thickness of the marble in southern Pennslvania and adjacent part of Maryland can only be estimated at 100 feet.

Rock exposed in a quarry east of Zumbrum School is impure grayish-white marble that resembles the Wakefield marble of the belt near the Maryland line.

Blue, thin-bedded, crystalline limestone that occurs in the valley east of Loganville has argillaceous bands which form slaty partings. It resembles the Silver Run limestone[61] of Maryland, where the blue limestone seems, in places, to grade into the Wakefield marble and the two may be equivalent. In this report the blue limestone will be included with the Wakefield marble.

The marble in the valley 1½ miles south of Chanceford is a greenish medium-grained calcareous schist composed of calcite, epidote, zoisite, chlorite and albite. It is closely folded and contains quartz lenses. The epidote is finely crystalline pale green, and occurs in thin layers. The rock exposed resembles the impure layers of Wakefield marble, next to the volcanic rocks, in Carroll County, Maryland.

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[60] Geologic map of Frederick County and adjoining parts of Carroll and Washington Counties, Md., Maryland Geol. Survey, 1938.

[61] Jonas, A. I., and Stose, G. W., New formation names used on the geologic map of Frederick County, Maryland: Wash. Acad. Sci. Jour. vol. 28, no. 8, p. 346, 1938.

Name and correlation.—The Wakefield marble takes its name from Wakefield Valley in western Carroll County, Maryland. It has been correlated with the Cockeysville marble of Baltimore County, Md. The Cockeysville marble is coarser grained and is overlain by the oligoclase-mica schist facies of the Wissahickon formation, and volcanic rocks are not associated with it. The correlation is not well established and the name Wakefield is therefore here used.

METABASALT

Distribution.—The metabasalt occurs in narrow areas in the albite-chlorite schist facies of the Wissahickon from a point southwest of Brownton southwestward to the Maryland line. The areas are narrow in the northeastern part of the belt, which is 6 miles wide from Glenrock southeastward. This rock is best exposed in several narrow bands in the valley of Codorus Creek and in road and railroad cuts from Glen Rock southeastward to Shrewsbury Station, but even there fresh exposures are few. Because it is less resistant to erosion than the inclosing Wissahickon formation, metabasalt occupies narrow longitudinal valleys between ridges of albite-chlorite schist and chloritoid schist. The metabasalt weathers readily to rusty porous blocks which are extensively used by the farmers in making stone walls. In southeastern York County, actinolite schist which may be related to metabasalt occurs in an area extending from Bald Eagle 2 miles southwestward along Bald Eagle Creek. The actinolite schist is exposed along the creek where it is infolded with the Wissahickon formation, but it was not possible to trace it on the upland to the southwest. Dr. E. B. Mathews reported that he found metabasalt in the Wissahickon formation in the river bed at Holtwood, where it was exposed during the construction of the power dam at that place, but the authors have not found any outcrops of metabasalt in the vicinity.

Character.—The metabasalt in York County is a green schistose rock composed of albite, uralitic hornblende, and epidote. It contains veins of quartz and epidote, and in the more massive outcrops shows amygdules filled with quartz and epidote. Thin sections under the microscope show albite, zoisite, and epidote, which are secondary to a lime-soda feldspar, and uralite and chlorite derived from pyroxene. The metabasalt is closely folded and crests of the folds are sheared out, forming foliation layers which generally dip 45° NW. This foliation is cut by slip cleavage which is nearly vertical. The actinolite schist at Bald Eagle contains garnet which has a rim of chlorite. This rock was described in a previous report [62] as a metamorphosed diabase or basalt and it was stated that no relations between the actinolite schist and mica schist were seen. Road cuts recently made show that the actinolite schist occurs in layers in the Wissahickon formation which is there a muscovite-chlorite schist containing garnet, and both rocks are closely folded. The axial planes of the folds are overturned, the axes pitch 20°-35° and the direction of the pitch ranges from S. 60° E. to S. 20° W. It is probable that the actinolite schist at Bald Eagle is altered basaltic lava related to that more extensively exposed to the southwest.

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[62] Knopf, E. B., and Jonas, A. I., Geology of the McCalls Ferry-Quarryville district, Pennsylvania: U. S. Geol. Survey Bull. 799, p. 62, 1929.

SERPENTINE

Distribution.—Serpentine occurs in a small area at Delta near the Maryland line where it is intruded into the Peters Creek quartzite. This serpentine is the northeast end of a narrow belt of serpentine that lies on the northwest side of the Peach Bottom syncline, whereas the larger "State line" serpentine belt lies southeast of that syncline. This area extends 1½ miles southwestward in Harford County, Maryland, and is not over 500 feet in width. The serpentine is quarried at Cardiff for polished ornamental building panels and for road metal. A smaller opening to the northeast is on the State line. In the Maryland[63] Survey report on the area it is stated that the serpentine terminates abruptly just over the State line in Pennsylvania, for wells drilled on its extension to the north did not strike serpentine but pass through chlorite schist of the Peters Creek quartzite.

In the area of the Peters Creek quartzite north of Peach Bottom near Susquehanna River actinolite schist occurs in strike with the serpentine near Delta. Soapstone or talc schist crops out on a hill ¾ mile southwest of Susquehanna River and 1½ miles northwest of the actinolite schist. The talc schist fragments can be traced in the field for about 220 yards and the farmer on whose land it occurs reports that he has found it in place when plowing. This occurrence is in strike with actinolite schist in Lancaster County 2½ miles to the northeast. A fruitless attempt was made to trace the talc schist southwestward. In nearby outcrops the Peters Creek quartzite was closely folded and fold axes pitched 30°-75° to the southwest so that the termination of the talc schist may be due to plunging folds.

Character and origin.—The serpentine at Delta is chiefly dark-green and is mottled with light green serpentine. It is much broken up and much slickensided, and contains magnetite. Serpentine from the area in Harford County was derived from an olivene-pyroxene intrusive rock or peridotite, in which the minerals have been altered to hornblende and serpentine that may compose the entire rock. The serpentine is usually shattered and full of joints and fractures, many of which are filled with carbonate.

The soapstone in the northwestern area near Susquehanna River is a schistose fine-grained light-green talc schist composed of fine-grained talc flakes and scanty chlorite. Where the chlorite is more abundant the rock is harder and darker green. In the small area to the southeast the rock is a chlorite-actinolite schst.

The periodotite from which the serpentine at the State line has been derived by alternation processes was intruded as a sheet along the strike into the Peters Creek quartzite and, as in many other areas, it dips with the foliation of the enclosing formation. Serpentine and soapstone are ferromagnesian differentiation phases of gabbro and all these rocks are widespread in Maryland. From relations seen elsewhere, it is known that the gabbro and serpentine are older than the Sykesville granite, which extends a short distance into Pennsylvania near Texas, near the "State line" serpentine area. Both the serpentine and granite intrude the Peters Creek quartzite, hence are younger than it. Their age and relations will be discussed later together with that of the rocks of Martic overthrust block.

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[63] Johannsen, A., Serpentines of Harford County: Maryland Geol. Surv. pt. 3, pl. 14, pp. 276, 286, 1928.

WISSAHICKON FORMATION

Distribution.—The Wissahickon formation occupies most of the southeastern part of York County, where it is dominantly an albite-chlorite schist. Its northwestern boundary starts from a point about a mile north of Bridgeville at Susquehanna River, and extends southwestward, passing north of Rockey, through Springvale, Graydon and Glenville. It lies southeast of the Marburg schist, and contains infolds of metabasalt and Wakefield marble. The southeastern boundary is the contact with the Peters Creek quartzite, extending from the mouth of Muddy Creek southwestward to the State line 1 mile east of Constitution.

The formation was named by F. Bascom from the exposures along Wissahickon Creek in Philadelphia where the rock is a biotite schist and gneiss. The Wissahickon formation extends southwestward from Wissahickon Creek, and occurs in Maryland, south of York County on the southeastern side of the Peters Creek quartzite. Because the Wissahickon schist seems to underlie the Peters Creek quartzite the schist on the northwest side of the Peters Creek quartzite in northern Maryland and York County was considered to be a part of the Wissahickon formation. Because the schist northwest of the Peters Creek occurs in a different metamorphic facies, it was called[64] the albite-chlorite schist facies and the schist southeast of the Peters Creek quartzite was designated the oligoclase-biotite schist facies. The best outcrops of the Wissahickon formation occur along Susquehanna River and in the valleys of the larger streams. Muddy Creek cuts across the strike and exposes good outcrops of the formation for a distance of 16 miles, extending from Springvale southeast to the contact of the Peters Creek quartzite, half a mile northwest of Bryansville Station. Good exposures are found also on South Branch of Muddy Creek, Deer Creek and in the southern part of the county on East and Middle Branches of Codorus Creek, which flow northwest.

Character.—The Wissahickon formation in York County is a coarse- to medium-grained, sparkling, grayish-blue, or green schist whose dominant minerals are albite, chlorite, muscovite, and quartz. It is interlayered with schistose quartzite and muscovite and chloritoid schists. In general the schists are coarser in grain in the southeastern part of the area and become finer grained to the northwest. The different kinds of schists represent in part, an original difference in composition and in part a difference in metamorphism. Because of close folding, different kinds of schists of the formation may occur in the same outcrops. On the map the schists have been separated into several generalized types and these types are delimited into zones which in part represent lithologic and structural units, and in part are the results of the polymetamorphism of the formation. It should be noted that the separation of these types of schists is a generalization made from the study of that part of the area in which fresh outcrops occur, aided by microscopic study of a few thin sections.

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[64] Knopf, E. B., and Jonas, A. I., Crystalline schists of Pennsylvania and Maryland: Am. Jour. Sci., vol. 5, pp. 46-48, 1923.

The description of the thin sections of the Wissahickon formation has been given in detail in the report on the Hanover-York district[65] and the McCalls Ferry-Quarryville district and will not be repeated here. The different kinds of Wissahickon albite schist are here designated was^1 to was^5.

was^1.—This is an albite-muscovite-chlorite schist which is contained in the area lying in general southeast of a line extending from York Furnace southwestward through Laurel and Stewartstown. It is a coarse-grained gray to greenish-gray albite schist spangled with muscovite, and contains chlorite, garnet, and quartz. Ilmenite and magnetite are usually present. Garnet is found in much of this schist and has rims of chlorite, in places visible to the unaided eye. The garnets rimmed with chlorite occur in fresh rock and the mineral alteration is not the result of weathering but represents a change in conditions of metamorphism during which the garnet was replaced by chlorite.

The schist is infolded with bluish-green schist containing fine or microscopic albite grains. At the southeastern border of the formation, near its contact with the Peters Creek quartzite, the albite-chlorite-muscovite schist is fined grained. The schist is closely folded and contains quartzose layers which were folded with the schist, and also thin quartzite layers, which are mapped to the southeast of Southside, where they crop out along Muddy Creek.

was^2.—Within the area of albite-muscovite-chlorite schist already described, there is a belt of another type lying along the axis the Tucquan anticline. It is a sparkling albite-muscovite-chlorite quartz schist that weathers rusty because of its content of ilmenite and iron oxide which band the rock with layers of microscopic opaque dust. This type of schist is well exposed along Muddy Creek from High Rock to Muddy Creek Forks and southwestward along South Branch of Muddy Creek where it occurs in recumbent folds with nearly horizontal axial planes, or in gently-dipping foliation layers produced by a shearing out of the folds. Near Susquehanna River the schist is fine grained and bluish green but under the microscope it was found to be of similar composition to the schist farther to the southwest. This schist also contains garnets, which in part have rims of chlorite. Two narrow areas of the ferruginous schist lie to the northeast of the larger area and pass through Laurel and Fenmore. The schist in these areas is finer grained than in the vicinity of Muddy Creek Forks.

was^3.—Bluish-green albite-chlorite schist containing muscovite and quartz forms the northeastern part of the Wissahickon formation in York County. In general the grain size of the minerals of the whole formation decreases toward the northwest. Coarse-grained albite-chlorite schist forms the southeastern part of the area of this type from Shenks Ferry southwest through Laurel and Stewartstown where the coarse grained albite schist extends northwest across the strike to

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[65] Stose, G. W., and Stose, A. J., Geology of the Hanover-York district. Submitted in 1938 to the U. S. Geological Survey for publication.

Shrewsbury station. The schist of the area from Susquehanna River southwestward along the strike to North Fork of Muddy Creek between Springvale and Felton is also coarse grained. Southwestward to Maryland line in the northwestern part of the belt the grain size is smaller. This decrease southwestward in the grain size of the albite-chlorite schist is along the strike and should not be confused with the previously mentioned decrease across the strike from southeast to northwest.

Garnets have not been noted in the albite-chlorite schist northwest of a line passing through Felton and York Furnace. Along Susquehanna River this type of schist contains biotite and muscovite in the area from Shenks Ferry northwestward for about four miles. Southwestward along the strike, chlorite and muscovite take the place of biotite. These differences in mineral composition and grain size show a variation in metamorphism both along and across the strike. The coarse-grained biotite and muscovite occur mostly as porphyroblasts that are later than the transverse cleavage because they are not bent by it, while the cleavage intersects the older constituents. The coarse muscovite spangles the schist in the hand specimen and tends to obscure the fact that the muscovite and chlorite formed earlier are finer grained.

The albite in all the types described occurs in coarse to fine metacrysts, somewhat rounded, which lie in the micaceous layers and contain a stream line of inclusions of such other minerals as make up the rock. They are usually garnet, epidote, muscovite, or iron oxide, and, in the case of the ferruginous schist of was^2, the inclusions are largely opaque dust composed of ilmenite and iron oxides. Some of the albite grains show under the microscope clear rims formed by later growth around the centers that are full of inclusions.

In the albite-chlorite schist of types was^1 and was^3 ilmenite occurs in well-crystallized prisms and thin laminae. In many places the prisms are included in chlorite and clinochlore porphyroblasts. It is possible that they are derived from an earlier mineral, either biotite or staurolite, although no relics of these minerals have been found.

was^4.—Throughout the Wissahickon formation in the area of was^3. chlorite-muscovite-quartz schist, was^4, is infolded with albite-chlorite schist. The map shows only a generalized separation of the two rocks. The chlorite-muscovite schist is bluish green, and southwest of Muddy Creek, is shiny and fine grained and lacks muscovite porphyroblasts which are present in it northeast of Muddy Creek.

was^5.—Chloritoid schist has been separated where the presence of chloritoid was determined microscopically, for that mineral is too fine grained for determination with the unaided eye except at the locality half a mile north of Hildebrand School where it is coarse grained. Much of the chloritoid is porphyroblastic and formed late in the folding.

Quartzite.—Quartzite occurs infolded with the albite-chlorite schist, chlorite-muscovite schist and chloritoid schist. The main areas lie in a belt from near Blackrock, passing north of Sticks and Glen Rock, extending to near Pleasant Hill Church, and from Rockey northeastward. Quartzite occurs also south of Felton, southwest of Otter Creek and southeast of Southside. Quartzite is in contact with metabasalt in two areas which cross Codorus Creek northwest of Shrewsbury Station. The quartzite is white, fine grained and contains blue or milky quartz grains and muscovite. In the areas northeast of Glen Rock and south of Felton the quartzite is conglomeratic and quartz pebbles, somewhat stretched, measure up to two inches long. The quartzite near Rockey is fine grained, with muscovite parting, and is closely crumpled. Where graphite is present in the quartzite it occurs as fine graphite dust and the rock has muscovite partings and weathers rusty.

Thickness.—The Wissahickon formation, as has been stated, contains schists of varying composition, crystallinity, and metamorphism which were folded into closely packed recumbent folds. The closures of these folds have been sheared out for the most part, and the limbs, in most places, have been torn apart by slipping movement. The prominent structure now seen in the schists is a wavy foliation. If the original layered structure of the argillaceous and quartzose series, which makes up the Wissahickon formation and which was folded into recumbent folds, was bedding, the foliation which is now chiefly parellel to the limbs of the recumbent folds is also largely parallel to original bedding. But because the original position of the layering, which perhaps is bedding, has undergone a complete transposition and inversion, the present superposition of layers is in no sense a stratigraphic succession. The foliation structure, formed as a result of the slipping movement that accompanied recumbent folding, has been folded into the Tucquan anticline and its minor folds during the rise of Mine Ridge arch. No estimation of thickness therefore, can be made and no vertical section of the formation can be given. The origin, correlation, and age of the Wissahickon formation will be discussed later.

MARBURG SCHIST

Distribution.—The Marburg schist crosses York County along the northwestern border of the Martic overthrust block in a belt about 5 miles wide. It enters the county near Long Level at Susquehanna River and is well exposed in cuts of the Pennsylvania Railroad along the river in Lancaster County from south of Creswell Station to south of Star Rock. It has been named from the village of Marburg 5 miles southeast of Hanover. In the report on the McCalls Ferry-Quarryville district the schist now called Marburg was included with the albite-chlorite schist facies of the Wissahickon formation and the schist in a small area near Long Level was called the Peters Creek formation. In the report on York County it has been separated from the Wissahickon formation which lies southeast of it because it is finer grained and in the southwestern part of the area contains schist apparently derived from volcanic tuff. The schists near Long Level were called Peters Creek formation because by their quartzose character they resemble the Peters Creek but, since the schists now called Marburg are known to be in part of volcanic origin and the Peters Creek quartzite has not been found to contain volcanic rocks in the type area southeast of the Wissahickon albite and chlorite schists, the quartzose schist near Long Level, previously called Peters Creek, is here included in the Marburg schist. The line of separation is dashed on the map because grain size and metamorphism decrease gradually from southeast to northwest. The associated quartzites in the upper part of the Marburg schist are exposed in the Yoe and Wentz synclines.

Character.—The Marburg schist is chiefly bluish-gray to silvery-green fine-grained schist which contains muscovite, chlorite, albite, and quartz, or muscovite, chlorite, chloritoid, and quartz. In the area northeast of East Branch of Codorus Creek the schist is coarser grained and sparkles with porphyroblasts of muscovite. The types of schist which comprise the Marburg are interfolded and in general, are separable only in thin section, hence are not separated on the map. Beds of quartzite and conglomerate form the upper part of the formation. Like the northeastern part of the Wissahickon formation the Marburg schist in the northeastern part of the area is coarser grained and contains sparkling muscovite porphyroblasts. To the southwest along the strike, southwest of East Branch of Codorus Creek, it is fine grained and the porphyroblasts, where present, are visible only with a hand lens.

The chloritoid schist variety of the Marburg schist is a fine-grained dense, grayish-green schist, composed of muscovite and quartz with chloritoid showing in thin section as dark prisms arranged in sheaves.

QUARTZITES ASSOCIATED WITH THE MARBURG SCHIST

Distribution.—Quartzites are closely infolded in synclines in the Marburg schist. The quartzites are interbedded with slate and schist, and form the higher hills in the Yoe and Wentz synclines. Quartzites underlie the ridges having an altitude of 800 to 1,000 feet on which Dallastown and Red Lion are built. A conglomeratic facies of the quartzite forms Huntrick, Beecher, and Saubel Hills, which range in altitude from 900 to 1,000 feet.

The area containing quartzite beds in the Yoe syncline lies northeast of Rye and Inners Creek, and is surrounded by the Marburg schist. Small areas of quartzite lie south of the main syncline, from Red Lion northeastward. The area containing quartzites in the Wentz syncline, named from a place in Maryland 1 mile south of West Manheim, extends from a point southwest of Loganville southwestward to the Maryland line, and is 12 miles long in Pennsylvania. At its widest point, north of Hokes Post Office, it is 2½ miles wide. Narrow areas of black slate half a mile south of Seven Valleys, southwest of Kinneys School, and south of Myers School, probably represent synclinal infolds of the slate which is interbedded with the quartzite in the Yoe syncline and near Zumbrum School. The slate has been quarried locally in the first two of these areas.

Character.—The quartzites consist of black slate interbedded with siliceous bands overlain by a thin green and rusty-weathering quartzite and thicker white to green quartzite with blue quartz grains. The uppermost beds, exposed only in the Wentz syncline, are a green schistose ferruginous quartz conglomerate with muscovite partings and quartz and slate pebbles.

In the Yoe syncline the quartzite beds are thin and in part interlayered in black slate. Coarser layers show blue quartz grains. The beds are closely folded and outcrops are poor and the beds cannot be traced as continous ledges. The black siliceous slate is made up of fine-grained chlorite, muscovite, and quartz, and contains chlorite porphyroblasts with large centers of ilmenite. A siliceous slate banded with blue quartz grains from Inners Creek southwest of Dallastown contains small aggregates of fine angular quartz in a dark matrix. These aggregates suggest the rock may be a tuff mixed with land-derived quartz.

The quartzites in the Wentz syncline are made up largely of dark ferruginous and green sericitic quartzite with interbedded blue and green slate, some beds of which contain blue or milky quartz grains, muscovite, and chlorite. A coarse, pebbly, green conglomerate in layers 2 to 4 feet thick, is interbedded with the dark quartzite and blue slate. The conglomerate is schistose and the blue and milky quartz pebbles are elongated, some being as much as 3 inches long. Muscovite and chlorite are developed on the partings. When weathered it is porous and rusty brown, owing to leaching out of its ferruginous cement. It contains flattened lenticular pebbles composed of quartz and sericite.

Conglomerate and interbedded green rusty quartzite are well exposed on highway 616, 1 mile southwest of Larue. The conglomerate layers contain quartz pebbles 1 inch long. The conglomerate beds and thicker quartzites are generally the only beds traceable on the uplands. In stream valleys thinner quartzites also may be seen in outcrop. Along Codorus Creek north of Brodbeck there is an almost continuous exposure for ¾ of a mile and the thickness of the quartzite is estimated to be about 150 feet. The section is complicated by folding and the exposures are too shallow and discontinuous to determine the structure. The section has been interpreted as follows:

Composite section of the quartzites at the top of the Marburg schist at Brodbeck

	Feet
Sheared conglomerate with pebbles up to 3 inches in size and hard, white, granular quartzite (conglomerate member)	25±
Green ferruginous quartzite and quartz schist containing glassy quartz grains in lower part	50±
Thick-bedded white to ferruginous quartzite containing blue quartz grains and small pebbles. Weathers porous and rust spotted	25±
Gray phyllite	20±
Thick-bedded granular white quartzite containing blue quartz grains with shiny shale partings, in part ferruginous, and weathers banded, porous, and rust spotted, with interbedded gray slate in lower part	30±
	150±

Green phyllite or platy slate, rust spotted from pyrite (Marburg) schist.

PETERS CREEK QUARTZITE

Distribution.—The Peters Creek quartzite underlies a belt 6 miles wide that covers most of the southeastern corner of York County. It is divided into two parts by the narrow area underlain by the Cardiff conglomerate and Peach Bottom slate. The northwestern boundary of the Peters Creek quartzite, at its contact with the Wissahickon formation, is roughly parallel with Muddy Creek from Susquehanna River southwest to a point half a mile northwest of Bryansville Station. From the sharp bend in the course of Muddy Creek the contact continues southwest to the State line, 1 mile east of Constitution. The Peters Creek quartzite is well exposed along Susquehanna River and its tributaries.

The Peters Creek quartzite was named from its fine outcrops along Peters Creek, a tributary to Susquehanna River in adjoining Lancaster County. Two narrow areas one of talc schist and the other of actinolite schist occur in the Peters Creek quartzite northwest of the slate belt and a small area of serpentine lies in the Peters Creek southeast of Delta. It is the northeastern end of a serpentine area that has a wider extent in Maryland and is quarried at Cardiff just south of the State line. Quartzite that is interbedded with the schist of the Peters Creek quartzite cannot be traced as continuous beds because of close folding and the absence of continuous outcrops on the upland. The quartzite is most abundant southeast of the area of Peach Bottom slate where it is well exposed along the Susquehanna River and the tributary streams and occurs in massive closely folded layers. The general trend of the quartzite is shown on the map by dashed lines.

Character.—The formation consist of a series of light, greenish-gray, muscovite, chlorite, quartz schists interbedded with quartzite which contains thin layers of muscovite and chlorite on the parting planes. The formation contains less quartzite in the northern part near the Wissahickon formation, but quartzite is infolded with muscovite-chlorite schist in that area between Muddy Creek and Peach Bottom. Southeast of the slate belt the formation is largely quartzite with infolded schist. The schist of the Peters Creek is difficult to separate from the albite-chlorite schist of the Wissahickon to the northwest, and the boundary between the two formations has been represented on the map by a dashed line.

Under the microscope the muscovite-chlorite-quartz schists of the Peters Creek quartzite are seen to contain quartz which is fine grained and clear. A fine foliation is imparted by muscovite and chlorite (a deep-green clinochlore). Albite, which is usually untwinned, is fairly abundant. It differs from the albite of the Wissahickon in that it is finer grained, not noticeably porphyroblastic, and not spongiform. Magnetite and titanite are abundant accessories, and apatite, pyrite, and tourmaline are of common occurrence. The quartzite layers contain numerous clastic grains of clear, blue quartz and in places quartz pebbles. Under the microscope the quartz pebbles show as deformed lenticular areas that are in some places clear, with slight strain shadowing, and in other places are completely granulated. The quartzite contains also sodic albite, microcline, muscovite, and chlorite.

Thickness.—Like the Wissahickon formation the Peters Creek quartzite has been folded into recumbent folds which are still preserved in the harder beds. In the schistose layers the prominent structure is a wavy foliation formed as the result of the slipping movement that accompanied recumbent folding. The major structure of the Peters Creek is synclinal. The fold axes and foliation dip into the Peach Bottom syncline that crosses the center of the area and contains the Cardiff conglomerate and Peach Bottom slate. No estimate of thickness of the Peters Creek quartzite can be given.

ORIGIN OF THE WISSAHICKON FORMATION, MARBURG SCHIST, AND PETERS CREEK QUARTZITE

The Wissahickon formation in York County is made up of crystalline schists formed by the metamorphism largely of argillaceous and arenaceous sediments. The different mineral contents of the schists reflect original differences in composition. The greater part of the formation is albite schist. Some of the schists contain much iron and titanium oxide, which occur as layers of fine opaque dust and in crystals and grains. In many places there is muscovite-chloritoid schist, without albite, and quartzites.

Chloritoid-muscovite schist and chlorite schist occur also in the Marburg schist along with fine-grained albite-chlorite schist. The chlorite and chloritoid schists southwestward along the strike in Carroll and Frederick Counties, Maryland, show evidence of tuffaceous origin. There, blue, purple, and green schists or phyllites containing chloritoid or chlorite and muscovite show tuffaceous structures and are interlayered with metahyolite, metabasalt flows, and tuffs. In York County tuffaceous characters are not evident in the Marburg schist. The blue, purple, and green phyllitic schists of the Marburg in the area south of the Jefferson syncline are very similar in appearance and composition to the tuffaceous phyllites of Maryland and may be in part of pyroclastic origin.

In Maryland tuffaceous phyllites in strike with the Marburg schist of York County lie northwest of the marble-volcanic belt which extends through Maryland northeastward into York County on the northwestern side of the Wissahickon formation. In the York County area the Wissahickon formation surrounds the northeastern end of the metabasalt and grades northward into the Marburg schist. It is possible that the chloritoid schists of the Wissahickon formation also may represent tuffaceous layers in that formation. The fine opaque dust layers and prisms, largely ilmenite and iron oxide, found in part of the Wissahickon formation, are an original constituent of the rock. Certain of the tuffaceous phyllites in Maryland similarly contain ilmenite as fine dust and in crystal form. This fact suggests that the schists of the Wissahickon with high titanium and iron oxide content may be of volcanic origin which has been obscured by metamorphism.

Both the Wissahickon formation and Marburg schist contain quartzites. Quartzites associated with the Marburg schist in the Wentz syncline, especially the conglomeratic variety, resemble conglomerates regarded as in part tuffaceous farther southwest in Maryland. The conglomerate layers of the quartzite in the Yoe syncline have flattened pebbles made of fine sericite and quartz in which the subangular quartz grains suggest a volcanic origin.

The conglomeratic quartzite in the Wissahickon formation, south of Felton and of Graydon, although it is more metamorphosed, resembles the quartzites associated with the Marburg schist. Muscovite of the matrix is coarser and the argillaceous pebbles are sheared out in the direction of the cleavage.

The Peters Creek quartzite, like the Marburg schist, is a metamorphosed series of argillaceous rocks with a large amount of quartzite. If the Peters Creek contains rocks derived from volcanic flow or tuffs, metamorphism has destroyed the evidence of such an origin.

Ordovician (?) system

CARDIFF CONGLOMERATE

Distribution.—The Cardiff conglomerate underlies the Peach Bottom slate, and forms a narrow band between the slate and the Peters Creek quartzite on the flanks of a hill area of slate, locally called Slate Ridge, that extends from Susquehanna River southwestward 4 miles to the Maryland line. In York County the conglomerate is a continuous band on the southeast side of the slate, but on the northwest side it is present in the county only in the vicinity of Delta. The name Cardiff was given to this conglomerate by the Maryland Geological Survey from the village of Cardiff, Md., on the State line, which is contiguous with Delta in York County. The conglomerate extends into Maryland on both sides of the shale belt for 3½ miles southwest of Delta to Pylesville, where it follows around the southwest end of the syncline in an elongate canoe-shaped end. The conglomerate also extends northeastward into Lancaster County,[66] where it borders the southeast side of the Peach Bottom slate area and encloses the northeast end of the syncline, 9 miles northeast of Susquehanna River. From Delta northeastward for 9 miles the Cardiff is absent on the northwest side of the slate belt.

In York County there are few exposures of the conglomerate, and its presence is indicated by blocks of conglomerate which strew the borders of the hill formed by the slate. It crops out on both sides of a small stream tributary to Deer Creek, 1½ miles east of West Bangor. To the southwest in Maryland the outcrop of the conglomerate widens to half a mile at Pylesville around the rising end of the syncline. Because the conglomerate breaks readily into slabs parallel to the muscovite partings, it has been quarried for building blocks in Maryland and for road material at several places southeast of Whiteford, where the headwaters of Deer Creek have cut valleys in the southeast side of the slate hill.

Character and thickness.—The Cardiff conglomerate is a quartz conglomerate with muscovite partings. It is greenish-gray where fresh and weathers to a mottled red. It contains quartz pebbles up to 3 inches long, which are somewhat drawn out parallel to the cleavage, and are rarely 1 inch thick. Most of the pebbles are completely granulated, but some show a core of clear glassy quartz, commonly of a bluish tinge, and many of the smaller pebbles and grains are clear all the way through. The matrix of the conglomerate is schistose, composed of fine quartz and fibres of muscovite and chlorite. Magnetite is very abundant under the microscope in some specimens, and titanite grains occur commonly. Vein quartz containing kyanite occurs in the conglomerate in Maryland, one mile south of Delta.

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[66] Knopf, E. B., and Jonas, A. I., op. cit., U. S. Geol. Survey Bull. 799, pp. 37-39, 1929.

The Cardiff conglomerate, like the Peters Creek quartzite that lies below it and the Peach Bottom slate that overlies it, is closely folded. Where outcrops were seen, east of West Bangor, the conglomerate occurs as thin and thick straight layers. The best section of the formation was seen ¾ mile southeast of Whiteford, Md., where the layers dip 85° NW. into the syncline. The section is as follows:

	Feet
Green quartz phyllite	20
Schistose conglomerate	2
Green phyllite	12
Schistose conglomerate	20
Black slate	3
Conglomerate	15
Covered to southeast	
	72±

Because the conglomerate is closely folded and the folds sheared out in large part, this section cannot be regarded as a stratigraphic sequence, nor as representing the thickness of the formation. In York County at places where outcrops are visible the conglomerate layers dip 60°-70° northwest into the syncline.

The absence of the conglomerate on the northwest side of the Peach Bottom slate in York and Lancaster Counties has been attributed to faulting.[67] In Lancaster County this explanation for the absence of the conglomerate on the northwest limb of the syncline seems reasonable. Another possible explanation of its absence on the northern margin of the slate in York County northeast of Delta is that the Cardiff conglomerate was not deposited in that area. The relations shown on the map northwest of Slate Hill are better explained by the latter theory than by a fault.

PEACH BOTTOM SLATE

Distribution.—The Peach Bottom slate in York County forms an area which extends from Susquehanna River southwestward for 4 miles to the Maryland line. Its maximum width is ¾ mile. The slates form a prominent ridge known locally as Slate Ridge, which passes through Slate Hill, West Bangor, and south of Delta. The slate is known to the trade as the Peach Bottom black roofing slate. The slate was named from Peach Bottom Station, Lancaster County, lying ¼ mile south of the slate area. The Peach Bottom slate overlies the Cardiff conglomerate, and occupies the center of the Peach Bottom syncline. The full extent of these 2 formations along the strike is 15 miles from the southwest end, ½ mile east of Pylesville, Maryland, to their northeast end in Lancaster County, 2 miles southwest of the West Branch of Octoraro Creek.

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[67] Knopf, E. B., and Jonas, A. I., op. cit., Bull. 799, p. 74.
Behre, C. H., Slate in Pennsylvania; Pennsylvania Topog. and Geol. Surv. Bull. M. 16, pp. 366-368, 1933.

An early report on these slates by Frazer[68] was followed by a discussion by Mathews[69] of the Peach Bottom slate in Pennsylvania and Maryland, with special emphasis on the quarrying operations. The slate in Lancaster County was described in 1929[70], and the later report of Behre[71] on the slate of the Peach Bottom district, Pennsylvania, covered the areas in both Lancaster and York counties.

Character and thickness.—The Peach Bottom slate is deep blue-black in color and finely lustrous on cleavage surfaces. That the color is unfading is shown by the preservation of the blue-black color of slates that have been exposed on roofs since the early part of the 18th century. Weathering over periods of geological time only cause the slate to turn dark brown or reddish. In the slate quarries where good cleavable slate is obtained, bedding is not easily recognizable because of the homogeneity of the rock and the well-developed slaty cleavage, but curved and irregular parting planes, called "slaunts" by the quarrymen, are usually discernible and seem to represent bedding, although no fossils have been found on these surfaces. The layering is most evident in the arches and troughs of the folds, where the layers dip gently and are cut across by the steeply dipping cleavage. (See Pl. 20.)

Partings, believed by some to be bedding, have been observed in some of the quarries in Maryland. Mathews[72] figures such curved partings in the Proctor Bros. quarry at Cambria, Maryland, and described them as bedding joints. From the picture here reproduced (Pl. 19 A) they closely resemble bedding. Behre[73] states that in the quarries in the western part of the Peach Bottom district in York County there are indications of several minor folds. He also describes and pictures the curved partings that are called "slaunts" by the quarrymen, which he states may be bedding. The writers also have observed partings and layering in some quarries that resemble bedding. In the Funkhauser quarry 1 mile northeast of Delta (Pl. 19 B), a layering that dips gently to the southwest may be bedding. In the Stasco Slate Quarry, Maryland, south of Delta, such layering is pronounced even in the workable slate in the main quarry, and is better displayed at the west entryway into the quarry, where the rock is not a good cleavable slate. The rock parts readily along these layers and a slight color banding parallel to the layering is well shown on the joint surfaces. (Pl. 20.) On the layering of the slate there is a fluting formed by the intersection of cleavage and the layering. (See Pl. 20 B.) The direction of the lineation on the fluted layers and on the cleavage planes shows the strike of the fold axes, and the

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[68] Frazer, Persifor, Jr., Geology of Lancaster County; Pennsylvania 2d Geol. Surv. CCC, pp. 182-190, 1880.

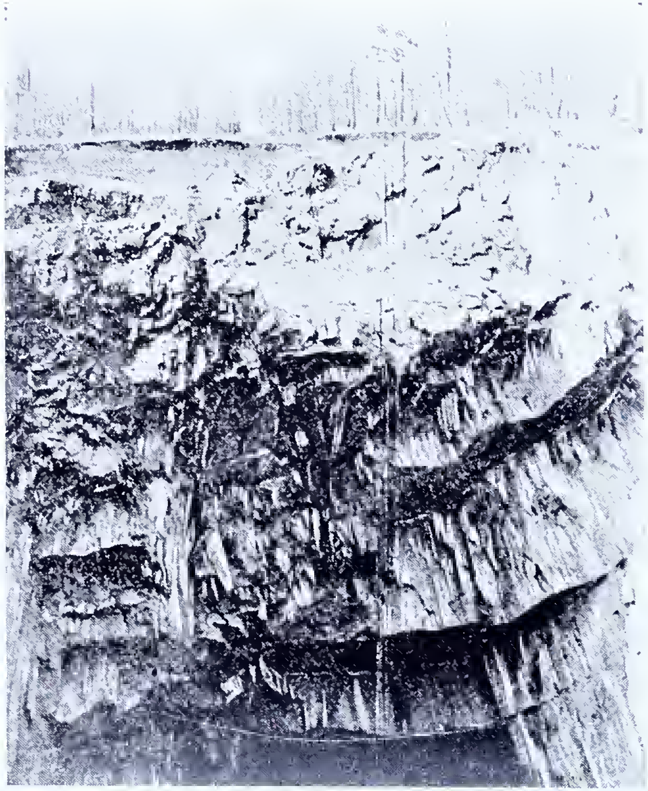
[69] Mathews, E. B., The character and distribution of Maryland building stones: Maryland Geol. Surv., pp. 214-231, 1898.

[70] Knopf, E. B., and Jonas, A. I., op. cit., U. S. Geol. Survey Bull. 799, pp. 39-41, 1929.

[71] Behre, C. H., op. cit., pp. 364-391, 1933.

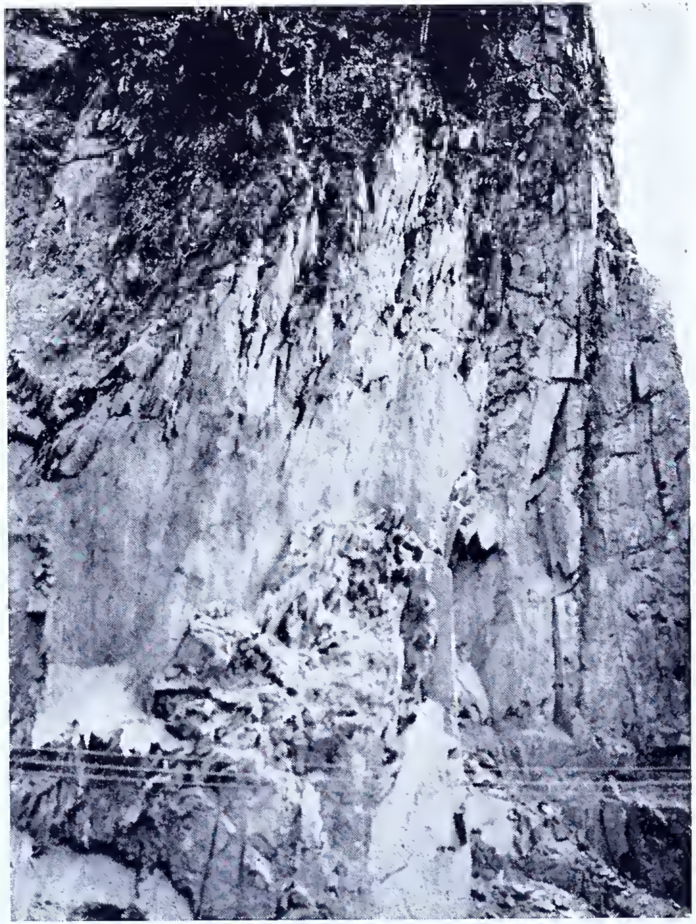
[72] Mathews, E. B., op. cit., pl. 31 and p. 223.

[73] Behre, C. H., Jr., op. cit., p. 368.

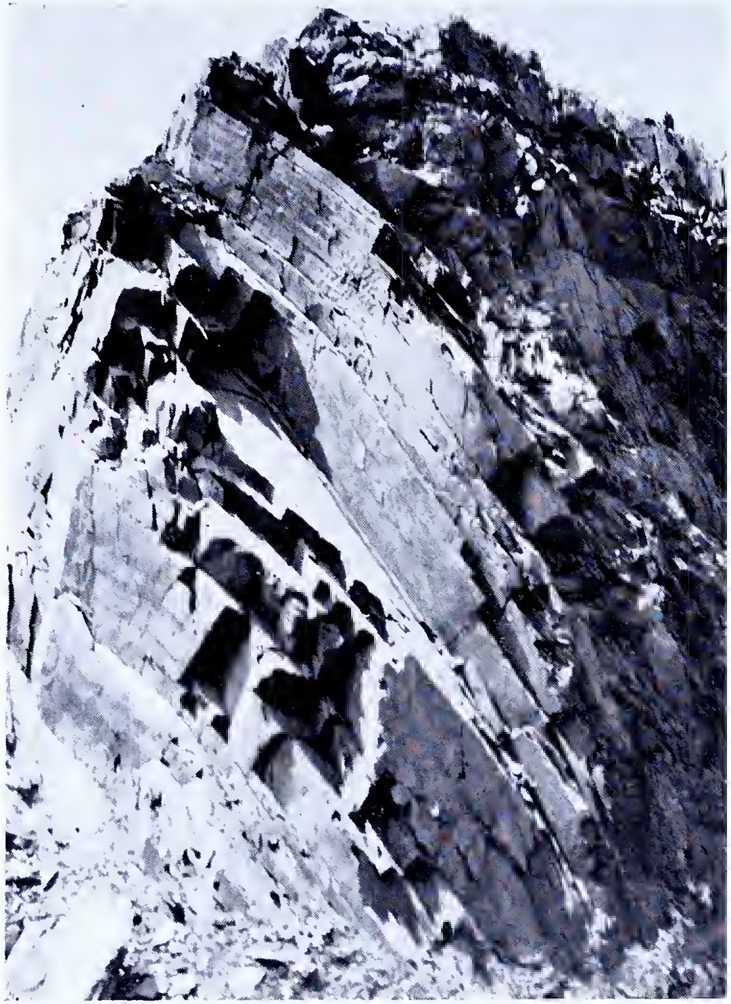


A. Peach Bottom slate showing probable folded bedding.

Proctor Bros. quarry, Cambria, Md.
(Photo by E. B. Mathews.)

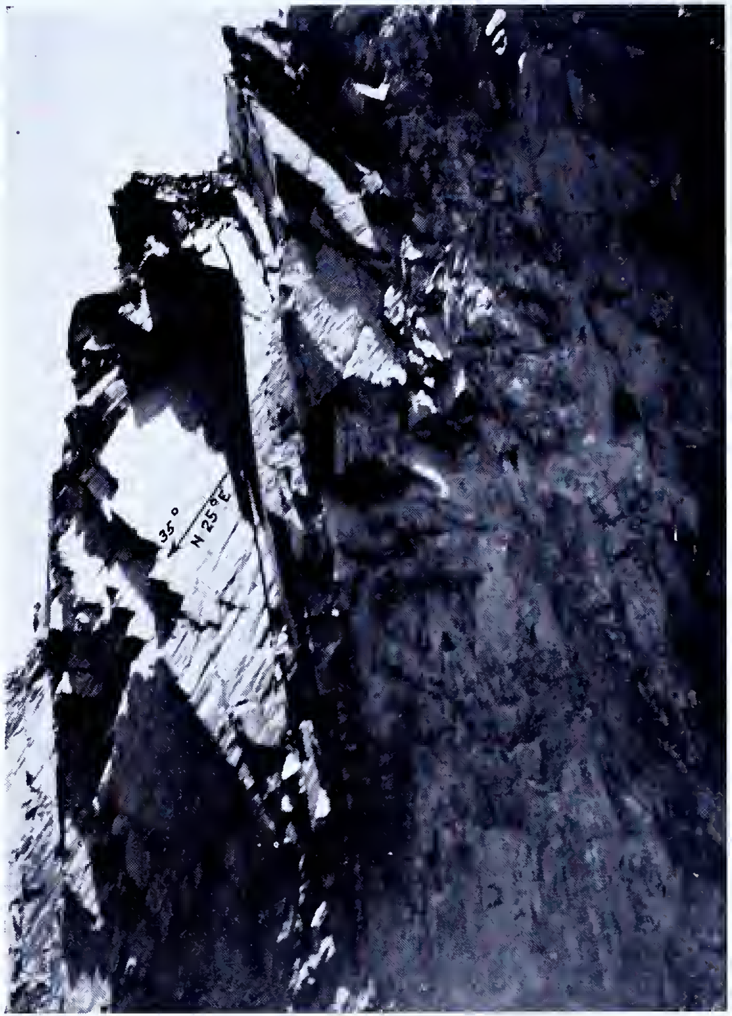


B. Peach Bottom slate showing probable bedding dipping low west (to left). Funkhauser quarry, Pa.



A. Probable bedding in lower beds of Peach Bottom slate.

Layering dips 45° NW. and folds pitch 35° NE. Entrance way to Stasco quarry, Whiteford, Md.



B. Another view of same outcrop shown in A.

Lineation on layers and fold axes dip 35° N. 25° E. Joint at right angles to this direction strikes N. 65° W. and dips 55° S. 65° W.

inclination of the lineation shows the pitch of the fold axes. In the Funkhauser quarry the lineation and, therefore, the fold axes are horizontal. Farther northeast the lineation dips southwest into the syncline. At the southwest end of the syncline in Maryland, and at the Stasco quarry near Whiteford, Maryland, the lineation and fold axes dip 35° N. 25° E. into the syncline. (See Pl. 20 B.)

A prominent joint system seen in the quarries is at right angles to the lineation and the axes of the folds, and the joints of this system form the walls of the entry way of the Stasco quarry, which is cut across the strikes of the slate. These joints are vertical where the lineation is horizontal, or dip steeply where the lineation is gently inclined. In many quarries two other joint systems, diagonal to the system first mentioned, are often present. The cleavage in the slate is uniformly nearly vertical, varying usually only 10° from the vertical, hence the axial planes of the folds are also nearly vertical. The shape of the general outline of the slate and conglomerate area indicates close minor folding of the syncline. At the southwest end of the area at Pylesville, Maryland, (fig. 5), the Cardiff conglomerate and the enclosed slate clearly lie in three minor synclines separated by 2 minor anticlines that pitch gently northeast. This folding is reflected in the distribution of the slate quarries. The linear arrangement of the narrow belts of workable slate suggests that the high-grade slate is related to the folds, and appears to lie in the center of the three minor synclines that are separated by the two minor anticlines, which accord with the position of the minor folds shown at the southwest end of the syncline. The northern belt of workable slate begins south of Cardiff, Md., where the Cardiff conglomerate makes a sharp bend southeastward around the end of the syncline, and ends at a point less than ¾ mile west of Slate Hill, where there are minor bends in the margin. The middle belt, which begins in a narrow infold of slate northeast of Pylesville, Md., terminates at a marked bend in the slate outline about ¾ mile northeast of Slate Hill. The southern belt begins in a synclinal fold of shale ¾ mile northeast of Pylesville and extends into Pennsylvania only a short distance, where it terminates in a sharp bend in the Cardiff conglomerate east of West Bangor. Workable slate is not enclosed in this belt northeast of this point, except at the top of the river bluff at the east end of the county. West of this point the syncline is very narrow and terminates in the gentle bend of the Cardiff conglomerate east of Slate Hill. The high-grade slate apparently occurs only in the center of the synclines where fine, even-grained, homogeneous, argillaceous sediments, which were susceptible to the development of good slaty cleavage, overlie the tougher basal beds of the formation. The basal beds seen in the abandoned quarries and on the surface of the hill northeast of Slate Hill are very finely quartzose, tough slate that splits with a hackly fracture and does not produce good cleavable slate. Nowhere is slate quarried in the basal beds of the formation near the margins of the slate area. Mathews[74] states that in Maryland a band of talcose chlorite slate lies between the roofing slate and the underlying quartzose conglomerate, and that the productive beds

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[74] Mathews, E. B., loc. cit., p. 222.

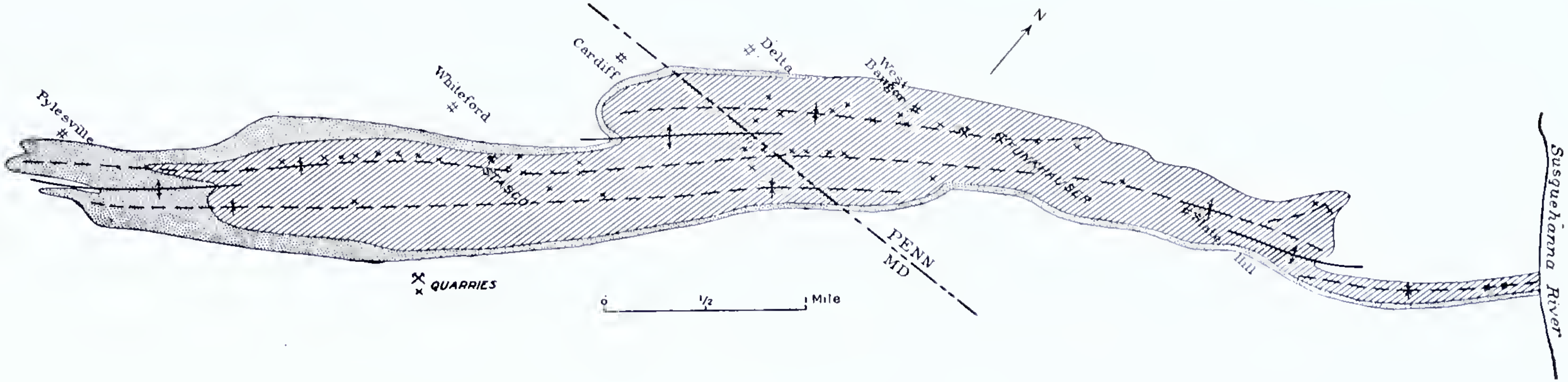

Figure 5. Geologic map of the Peach Bottom syncline showing structural axes. Dotted pattern, Cardiff conglomerate. Ruled pattern, Peach Bottom slate.

are thought to lie in the axis of a narrow overturned synclinal fold. Behre[75] states that the lower beds of the formation carry thin quartzitic beds, rarely more than ½ inch thick, which may be seen in old quarries on the Jones' estate, ½ mile south of Delta.

Although the lower part of the slate is in places finely quartzose, the writers have not noted the thin quartzites mentioned by Behre. They have seen, however, quartz veinlets parallel to the layering of the slate along the margin south of the slate area, in the entry way to the Stasco quarry, Md., in the northwestern part of the Funkhauser quarry, in abandoned quarries in the hill north of Slate Hill and at Susquehanna River, and in road cuts. The quartz veins range in thickness from a mere film to ¾-inch layers. The layers and the quartz veinlets at these places are closely crinkled and cut by a transverse cleavage. In places the quartz vein is parallel to the cleavage and shows shearing along it.

The age and correlation of the Cardiff conglomerate and Peach Bottom slate are discussed in the following chapter on the age and relation of the rocks of the Martic overthrust block.

Age and relations of the rocks of the Martic overthrust block

The rocks of the Martic overthrust block in York County are a series of crystalline schists which include the Wakefield marble, Wissahickon formation and Peters Creek quartzite, Marburg schist, and volcanic flows and tuffs. These rocks belong to the Glenarm series, which is composed of crystalline schists dominantly argillaceous and arenaceous in composition. The Wakefield marble and Cockeysville marble are the only carbonate rocks in the Glenarm series, and represent only a small part of it. Granitic rocks intrude rocks of the Glenarm series in Maryland and Pennsylvania but do not occur in York County. Serpentine intrudes the rocks of the Glenarm series in southern York County and together with gabbro and other ferromagnesian rocks occupy wider areas in the series elsewhere in Pennsylvania and in Maryland. So far as known the rocks of the Glenarm series contain no fossils. Cardiff conglomerate and Peach Bottom slate are infolded with the rocks of the Martic overthrust block but are not included in the Glenarm series.

The crystalline schists of the Glenarm series lie southeast of Paleozoic carbonate rocks of the Hanover-York valley and the underlying arenaceous Lower Cambrian rocks at their base. These Paleozoic limestones and dolomites, which will be referred to as the carbonate sequence, form synclinal valleys in York County in the vicinity of Hanover and York and in the Great Valley northwest of the Triassic rocks. Eastward they form the Lancaster, Quarryville, and Chester valleys.

The carbonate sequence and the underlying Lower Cambrian arenaceous rocks at its base contain Paleozoic fossils. These sediments contains no effusive rocks in York County. Intrusive rocks are absent except for scanty pegmatite in its basal sediments in Lancaster County and Triassic dikes. The crystalline schists of the Glenarm series lie southeast of the rocks of the carbonate sequence, and along their contact, from Schuylkill River southwestward to the Maryland line, in the southwestern part of York County. The schists of the Glenarm series lie southeast of and appear to overlie Harpers phyllite, Vintage dolomite, and Conestoga limestone. Their contact therefore is not a conformable one. Structural evidence given later in the chapter on structure of the county shows that the schists of the Glenarm series were deformed into recumbent folds, probably during their forward movement, when they were overthrust on the Martic overthrust fault and came to lie on the rocks of the carbonate sequence. This recumbent folding is an earlier phase of the deformation that culminated in arching and folding of the Paleozoic rocks and the underlying pre-Cambrian rocks together with the overthrust crystalline schists of the Glenarm series, so that the conformity of direction of the fold axes in the schists of the Glenarm series with those of the underlying carbonate sequence is no evidence for or against the transported or in situ origin of the rocks of the Glenarm series.

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[75] Behre, C. H., loc. cit., p. 364.

The rocks of the Glenarm series and carbonate sequence do not have the same lithology; the contact of the schists of the Glenarm series and the rocks of the carbonate sequence is not a conformable one and the writers have concluded that the discordance of the contact is not caused by sedimentary overlap but by overthrusting.

Age of the rocks of the Glenarm series.—In a preliminary paper on the marble-volcanic area of Carroll and Frederick Counties,[76] Maryland, the quartzites of Sugarloaf syncline were regarded as Lower Cambrian and their occurence in the synclines in the marble-volcanic area was cited as proof of the pre-Cambrian age of the marble-volcanic series and of the Glenarm series of which the marble-volcanic series is a part. Later work in the area has led the writer to regard all but the uppermost of these quartzites as a part of the volcanic series and equivalent to similar quartzites in the York County area described in this report as quartzites associated with the Marburg schist. In Sugarloaf Mountain, Maryland, thick white quartzites are interbedded with slates and arenaceous rocks, probably tuffaceous in part. The youngest quartzite present is a massive white quartzite which caps the highest peak of the mountain. These quartzites have been called Lower Cambrian since the days of J. P. Lesley and G. H. Williams (1892), but they have yielded no fossils. Since the Cambrian age of these quartzites has not been proved, this evidence for the pre-Cambrian age of the rocks of the Glenarm series has little weight.

In Virginia there are two areas of fossiliferous slates of Cincinnatian age that are infolded with schist of the Glenarm series. The slate of the eastern area that passes through Quantico along the Coastal Plain border overlies greenstone schist and granite gneiss. The north end of these slates is only 18 miles southeast of Potomac River at the District of Columbia line. The slate of the western area, the Arvonia slate of Buckingham and Fluvanna Counties, lies along the axis of the Peach Bottom syncline. The Arvonia slate with a thin basal conglomerate overlies the Columbia granite[77] of the Virginia Survey and the Peters Creek quartzite which that granite intrudes. Because the basal conglomerate lies on the bevelled edges of the Peters Creek and Columbia granite, it is evident that these underlying rocks are separated from the rocks of Cincinnatian age by an angular unconformity and they are both older than Cincinnatian for the Peters Creek quartzite was intruded by granite, was uplifted, and was eroded before the Arvonia slate was deposited. The Peters Creek quartzite is therefore considerably older than the Arvonia slate and is pre-Cincinatian in age, that is pre-Eden, hence neither the Peters Creek quartzite, which is the upper part of the Glenarm series, nor the Glenarm series itself can be equivalent to the Martinsburg shale as has been suggested,[78] for the Martinsburg shale whose basal beds are of Trenton age is in large part Eden in age and this group is the lower part of the Cincinnatian series.

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[76] Jonas, A. I., Pre-Cambrian rocks of the western Piedmont of Maryland: Geol. Soc. America Bull., vol. 35, pp. 361, 363, 1924.

The Columbia granite of the Virginia Geological Survey extends northeastward in interrupted outcrop to Potomac River, in strike with the Sykesville granite of Maryland which crosses that river west of Washington. The Columbia granite and Sykesville granite are lithologically similar, they occur along the same strike, and both intrude the Peters Creek quartzite and are both younger than the diorite and metagabbro and serpentine which also intrude the Glenarm series in Pennsylvania, Maryland and Virginia. The Columbia granite and Sykesville granite therefore are regarded as equivalent. The Sykesville granite intrudes the Peters Creek quartzite and extends northeast across southern Maryland to east of North Branch of Potapsco River into Baltimore County. Along the same strike to the northeastward granite, probably of Sykesville age, intrudes both the Peters Creek quartzite and the Wissahickon formation. This granite has formed mixed rocks with schists of the Peters Creek in a belt that lies on the northwest side of the "State line" serpentine belt. The "granitized" schist of the Peters Creek quartzite enters Lancaster County near Texas* where it forms only a small area and occurs on Susquehanna River in Maryland a short distance south of York County. If the Sykesville granite is equivalent to the Columbia granite, it is older than the Cardiff conglomerate and Peach Bottom slate, although this assumption cannot be provided by the field relations in York or Lancaster County where Peters Creek adjoining the Cardiff conglomerate is not intruded by granite. Serpentine intrudes the Peters Creek quartzite in southern York County and from relations seen elsewhere it is known to be older than the Sykesville granite, hence if the Sykesville granite is equivalent to the Columbia granite of the Virginia Survey the serpentine is also pre-Cincinnatian in age.

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[77] Brown, C. B., Outline of the geology and mineral resources of Goochland County, Virginia: Virginia Geol. Surv. Bull. 48, p. 14, 1938.

[78] Mackin, J. H., The problem of the Martic overthrust and the age of the Glenarm series in southeastern Pennsylvania: Jour. of Geol., vol. XLIII, p. 358, 1935.

Miller, B. L., Age of the schists of South Valley Hills, Pa.: Geol. Soc. Amer. Bull. vol. 46, p. 754, 1935.

* See Geological map of Pennsylvania, 1931

Cloos[79] as a result of structural studies along Susquehanna River near Port Deposit, Maryland, distinguished two structures in the crystalline schists of the area, which he calls flow and fracture cleavage. He considers that these structures are the same as the two structures found in the Ordovician (?) Conestoga limestone and that the folding in both series is post-Conestoga. Also he states that the foliation in these intrusive rocks is a primary structure and that the intrusives in part cross cut the schists they intrude. He concludes that the igneous rocks near Port Deposit were intruded later than the last folding of the area and that they are post-Conestoga in age.

The same conclusions were stated by Cloos,[80] H. G. Hershey, and J. Marshall, in a report which contains a general discussion of the crystalline rocks of Maryland and detailed studies of the Port Deposit granite (granodiorite) and the volcanic complex of Cecil County, Maryland.

Cloos states (p. 80) that "metamorphic igneous rocks occur sparingly" in the Piedmont of Maryland; that the Ellicott City granite (p. 79) is a primary gneiss whose banding is due to magma movements during intrusion. Although the "foliation (p. 131) in the intrusives (of the Port Deposit granodiorite complex) roughly parallels the general regional strike and flow cleavage in the Glenarm series" the flow structures in the Port Deposit granite "are thought to be largely primary."

Even if the post-Lower Ordovician age of the intrusives could be proven, such a determination would not add any evidence as to the age of the Glenarm series. The conclusions of C. J. Cohen[81] in the same volume as to the structure of the metamorphosed gabbro complex at Baltimore do not agree with those of Cloos and Hershey. Cohen states (p. 232) that the gabbro has a primary banding and a secondary cleavage, which do not conform to each other. While all the primary banding does not conform to structures outside the gabbro area, later structures in the gabbro and wall rock are conformable, and he concludes as follows (p. 235): "The author believes that the secondary structures in the gabbro complex have been superimposed on primary flow structures during a period of general regional metamorphism of the crystalline rocks of the Piedmont Province." The "Editor" (p. 236) modifies this statement by adding "but in close adherence to local conditions . . ." Recently Ingerson[82] has made fabric studies of the Port Deposit granite (granodiorite), its zenoliths and of the adjoining formation and states that the mica and quartz fabrics in the Port Deposit granodiorite and in the zenoliths are nearly identical and that this identity of fabric was produced during folding and metamorphism after the intrusion was completed. The age of the Port Deposit granodiorite is fixed by these results only as prefolding but its age is not necessarily post-Beekmantown, as was claimed by Cloos. It is probably pre-Cincinnatian in age like the Columbia granite of Virginia.

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[79] Cloos, Ernst, and Hershey, H. G., Structural age determinations of Piedmont intrusives in Maryland: Nat. Acad Sci. Proc., vol. 22, pp. 71-80, 1936.

[80] Cloos, E., and others, Maryland Geological Survey, vol. 13, pp. 27-146, 189-211, 1937.

[81] Cohen, C. J., Maryland Geol. Survey, vol. 13, pp. 215-235, 1937.

[82] Ingerson, Earl, Comparison of the fabrics of zenoliths and the adjacent intrusive rock. Abstract: Am. Mineralogist, vol. 23, no. 12, pt. 2, pp. 8-9, 1938.

The views held by F. Bascom, A. C. Hawkins, B. L. Miller and J. H. Mackin as to the age of the rocks of the Glenarm series has been fully discussed by the writers in their report on the Hanover-York district (to be published by the U. S. Geological Survey) and will not be repeated in this report. The Glenarm series is known to be pre-Eden in age but its pre-Cambrian age is not proven by any facts known to the writers. Lacking positive evidence to the contrary, the Glenarm series in this report will be called pre-Cambrian(?).

Age of the Peach Bottom slate and Cardiff conglomerate.—The Cardiff conglomerate and the Peach Bottom slate of Maryland and Pennsylvania were included in the Glenarm series and designated as pre-Cambrian by the U. S. Geological Survey and Maryland Geological Survey in 1923.[83] This was done because the writers were unable to find any evidence of unconformity at the base of the Cardiff conglomerate and although specimens of *Buthotrephis flexuosa* were mentioned by Lesley[84] as having been found in the Peach Bottom slates, the specimens could not be located and no other fossils have been obtained from the area.

The Peach Bottom slate and Cardiff conglomerate occur in the same syncline as the Arvonia slate of Virginia and both slates overlie Peters Creek quartzite with a conglomerate at the base. The Peach Bottom and Arvonia slates are lithologically similar and are high-grade roofing slates. Both are underlain by quartz conglomerates, although the Cardiff conglomerate is thicker and more prominent than the conglomerate at the base of the Arvonia slate. Faunal evidence shows the Arvonia slate is of Cincinnatian age and it seems probable that the Peach Bottom slate also may be of Ordovician age and may be equivalent to the Arvonia slate. The writers therefore regard the Peach Bottom slate and Cardiff conglomerate as of probable Ordovician age and do not include them with the underlying rocks of the Glenarm series.

MESOZOIC AND CENOZOIC ROCKS

TRIASSIC SYSTEM*

Newark Group

The rocks of the Newark group are prevailingly red sandy sediments, ranging from arkose, sandstone, and conglomerate to clayey sandstone and shale. These different kinds of sediments are variable in occurrence and change rapidly both laterally and vertically. A distinctive bed can generally be traced only a short distance at the surface.

The Newark group forms a wide area which extends from the New York-New Jersey state line southward across New Jersey, Pennsylvania, and Maryland, into Virginia. Throughout much of this area the upper part of the group is prevailingly argillaceous and shaly and the lower part prevailingly sandy, but within each of these broader units zones of conglomerate beds, most of them quartzose but some composed largely of limestone pebbles, and purer gray sandstone are present and mappable.

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[83] Knopf, E. B., and Jonas, A. I., Stratigraphy of the crystalline schists of Pennsylvania and Maryland: Am. Jour. Sci. vol. 5, pp. 40-62, 1923.

[84] Lesley, J P., Age and position of the Peach Bottom slates: Amer. Phil. Soc., Pr., vol. 18, pp. 364-369, 1879.

* Data on the Triassic rocks from a preliminary report on the New Cumberland quadrangle by M. H. Bissell have been incorporated in this report.

In New Jersey three well-defined formations have been recognized,[85] named in ascending order—Stockton formation (series), Lockatong formation (series), and Brunswick shale. The Lockatong formation, the most distinctive, is characterized by hard, calcareous dark argillite or hard argillaceous shale. The beds above are generally more shaly than those below. These formations have been traced and mapped southwestward to a point about 30 miles west of Philadelphia where the Lockatong thins and gradually disappears. The lithology of the overlying Brunswick shale also changes at about this point, thick coarse conglomerate beds displacing much of the shale.

In southern Pennsylvania the Newark group is divided[86] into two units, a lower more sandy and arkosic division, called the New Oxford formation, and an upper more shaly division, called the Gettysburg shale. This broad division of the Newark group into two formations can be recognized northeastward to eastern Pennsylvania and southwestward into Maryland, but the dividing line between them is more or less arbitrary and varies somewhat in stratigraphic position from one area to another. Within each formation there are minor units which are traceable for several miles, and these have been mapped as members. The New Oxford formation and the Gettysburg shale correspond approximately with the Stockton and Brunswick formations of eastern Pennsylvania and New Jersey. This twofold subdivision of the Newark group first recognized in the Gettysburg area has been traced eastward across York County, but the dividing line is made doubly difficult to trace by the occurrence of a thick conglomerate near this boundary line and by the disturbance and metamorphism of the beds by the intrusion of thick diabase sills and cross-cutting bodies. The subdivision recognized and mapped in the county are as follows:

An upper formation—the Gettysburg shale—of red shale and red sandstone, with a lenticular zone near the base containing thick beds of conglomerate and called the Conewago conglomerate member, a series of hard gray sandstones near the middle, called Heidlersburg member, and beds of limestone conglomerate and quartzose fanglomerate at the top; a lower formation—the New Oxford formation—of arkosic sandstone, with several conglomerate beds at and near the base.

The Newark group forms a belt about 15 miles wide that crosses the northwestern part of the county in an east-northeast direction. Intrusive diabase masses and adjacent hardened, metamorphosed shales of the Newark group make some of the highest hills in the area, of which Roundtop, 1,380 feet altitude, is the highest, and Nells Hill, Flat Mountain, and Pinetown Hill are about 1,200 feet and Blair Hill and Ramsey Hill about 1,100 feet. The sedimentary beds invariably dip NW. at an average angle of 25°, varying generally between 40° and 20°. The beds were deposited in a nearly horizontal position but were tilted northwestward by progressive sinking of the floor of the basin and downfaulting of its northwestern margin, as illustrated diagrammatically in figure 6. The total aggregate thickness of beds in the Newark group is estimated to be about 16,000 feet, but, because of the progressive sinking of the floor of the basin and the resulting overlap of beds as the center of sedimentation moved northwestward, this total thickness is not present at any one place.

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[85] Kummel, H. B., Annual Rept. of State Geologist of New Jersey for 1896, pp. 34-59, 1897.

[86] Stose, G. W., op. cit. (Fairfield-Gettysburg folio), pp. 8-11, 1929.

NEW OXFORD FORMATION

Distribution.—The New Oxford formation occupies a belt of low upland 4 to 6 miles wide that crosses the country in a northeasterly direction just north of the Pigeon and Hellam Hills. Its southern boundary is somewhat irregular but has a general N. 50° E. trend. In the area between the Pigeon and Hellam Hills, where the formation rests on Paleozoic limestones, the southern boundary swings farther south because of the more gentle slope of the floor of the basin on these softer rocks. The southern edge of the Triassic rocks here is marked by low hills that rise about 60-80 feet above the adjacent limestone lowland. The north boundary of the formation is a rather straight strike line, trending N. 55° E. with minor offsets. This low upland is 500-560 feet in altitude and is trenched to depths of 50-200 feet by Conewago and Little Conewago Creeks and their tributaries. Most of these valleys have gentle slopes, but those in the vicinity of Conewago Creek are narrow and steep sided.

Character and thickness.—The New Oxford formation is composed of red shale and light-red to buff sandstone and interbedded arkosic sandstones. The arkosic beds, which are the characteristic features of the formation, are composed of grains of glassy quartz and white kaolinized feldspar, and sparkling flakes of sedimentary mica. The arkosic sandstones are generally of grayish to greenish color but weather to a deep-buff. They are somewhat harder than the enclosing beds and therefore form low ridges. The alternation of buff-colored arkosic layers on low hills and ridges and contrasting red shale in the intervening swales is a striking feature of the landscape along roads that cross the strike. In the lower part of the formation are many beds of fine conglomerate and coarser pebble beds. These are thickest and most numerous northwest of the Pigeon Hills, and a coarse basal conglomerate resting on a steep floor rises 100 feet on the flanks of these hills, and makes a low bench on the slope in most places. There are several beds of conglomerate in the lower part of the formation, some of which extend northeastward 6 miles beyond the east end of the Pigeon Hills. The pebbles are mostly of rounded quartz and quartzite. The pebbles of the basal conglomerate on the north slope of the Pigeon Hills are coarser and less rounded than those in conglomerates higher in the formation, and the surface on which the conglomerate rests rises abruptly, indicating a local steep slope of the floor of the basin at this point. The pebbles of the conglomerate evidently were derived from the weathering and erosion of the Cambrian quartzite that composes these hills.

A basal quartzose conglomerate also occurs at the northwest foot of the Hellam Hills near Susquehanna River, and similarly laps up on the steep slopes of those eroded quartzite hills. The basal conglomerate extends northeastward beyond the end of the Hellam Hills, and in the limestone lowland beds of limestone conglomerate form its basal beds. Where the formation rests on Paleozoic limestone, as on State highway 74, 3 miles northwest of York, limestone conglomerate is locally present at the base but has not been mapped. In Adams County west of the Pigeon Hills, 2 miles west of the York County line, there is a fossiliferous black carbonaceous shale interbedded with limestone conglomerate and red shale at the base of the formation where it overlies limestone. A similar fossiliferous black shale near the base has been observed in York County, ½ mile west of Farmers.

The actual contact of the basal beds on the older rocks is generally not exposed. The basal conglomerate may be seen resting unconformably on the Cambrian quartzite and pre-Cambrian metabasalt at several places on the north slope of the Pigeon Hills south of Abbottstown. Layers of conglomerate with pebbles up to 3 inches in size interbedded with reddish arkosic sandstones, dipping gently northwest, may be seen resting with marked unconformity on the older quartzite, slate, or volcanic rocks. One of the best exposures of the basal beds of the Triassic resting on pre-Cambrian amygdaloidal metabasalt is in a small valley south of Maple Grove School, where the section is as follows:

Section of basal Triassic beds south of Maple Grove School

	Feet
Soft red sandstone	
Harder red sandstone	3
Soft red sandstone	6
Two beds of hard granular red sandstone with a bed of conglomerate composed of 1-inch quartz pebbles at base	8
Concealed	25±
Conglomerate and hard quartzose sandstone	35±
Hard coarse conglomerate	15
Soft yellow-weathered crumbly arkosic sandstone	20±

Unconformity
Dark spotted amygdaloidal slate
Massive epidotic amygdaloidal metabasalt

Some of the hard arkosic sandstones in these basal beds are so quartzitic that they closely resemble the Cambrian quartzite and are distinguished with difficulty from the Cambrian rocks on which they overlap.

The contact between the Triassic red beds and the Paleozoic limestone is seldom exposed because the limestone does not crop out and the basal Triassic beds are here generally soft and crumbly, probably due to fine calcareous particles in the red sediments. On the Dover Road (State highway 74), below the crest of Kohlers Hill 2 miles northwest of West York, limestone conglomerate with red sand matrix occurs a few feet above the limestones of the Kinzers formation but the contact is not exposed. Many of the limestone pebbles in this conglomerate are 3 inches in size. Just west of a school house 1 mile south of Roundtown, the basal beds of the Triassic are exposed in a small quarry. The quarry is in Cambrian limestone which dips 20° S. and at the top of the quarry face it is overlain by red shale, light-colored arkose, and harder pebbly red sandstone which dip 20° N. In the cut of the Pennsylvania Railroad at Emigsville north-dipping red sandstone and yellow arkose at the base of the Triassic may be seen resting on Antietam quartzite, but the Triassic beds are interrupted by a normal fault which brings Tomstown limestone to the surface to the north, and the basal Triassic beds are repeated. In the Pennsylvania Railroad cut on the west side of Susquehanna River, 1 mile northwest of Saginaw, quartzose conglomerate, red sandstone, and limestone conglomerate with red sandy matrix form the base of the Triassic, but the contact with the limestone floor is not exposed.

Some of the conglomeratic beds interbedded with the arkosic sandstone contain small fragments of carbonized plant remains and films of coal. A lenticular bed of conglomerate in which films of coal occur is exposed in a quarry 1 mile northeast of Mount Wolf. The bedding of much of the arkosic sandstone is irregular and ill defined, and cross bedding is common, so that the dip of the beds in places is hard to determine. A carbonized branch 1/16 inch thick was collected from the dump of the old Le Crone copper mine, 1¼ miles south of Zion View. (See pl. 21 A.) Thin coal seams or films were also reported in wells dug at Kohlers Hill. Some of the beds are calcareous, and a few thin beds of limestone up to 1½ inches thick occur about ¾ mile northwest of Zion View, near the top of the New Oxford formation. The limestone is nearly black, and is coarsely crystalline, the cleavage planes being distinctly curved. It occurs close to a diabase dike, and the coarse crystallization and curved cleavage may be due to recrystallization caused by the diabase intrusion. An analysis of a sample of this limestone made by Prof. J. L. Crenshaw of Bryn Mawr College is as follows:

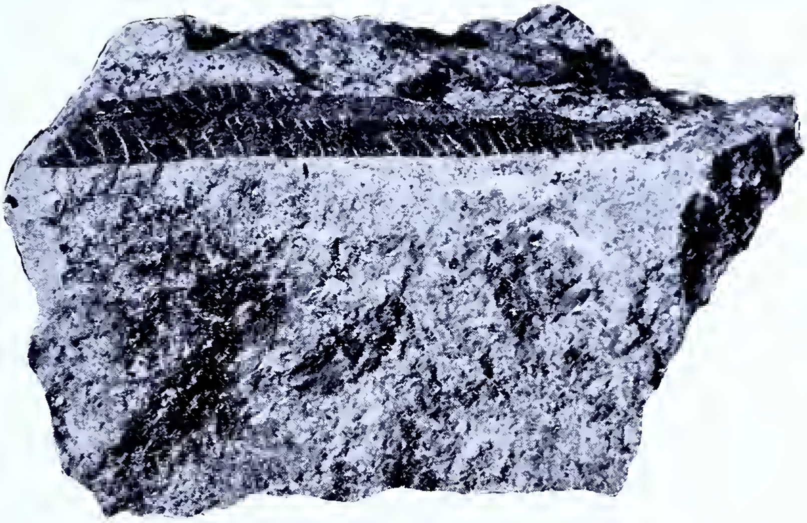
Analysis of Triassic limestone from Zion View, York County

[J. L. Crenshaw, analyst]

SiO_2	4.87	Na_2O	.16	P_2O_5	.02
Al_2O_3	1.26	K_2O	.08	Cl	.01
Fe_2O_3	.57	H_2O	.70	MnO	2.74
MgO	1.43	CO_2	40.44	C	.20
CaO	47.92	TiO_2	.07		
					100.47

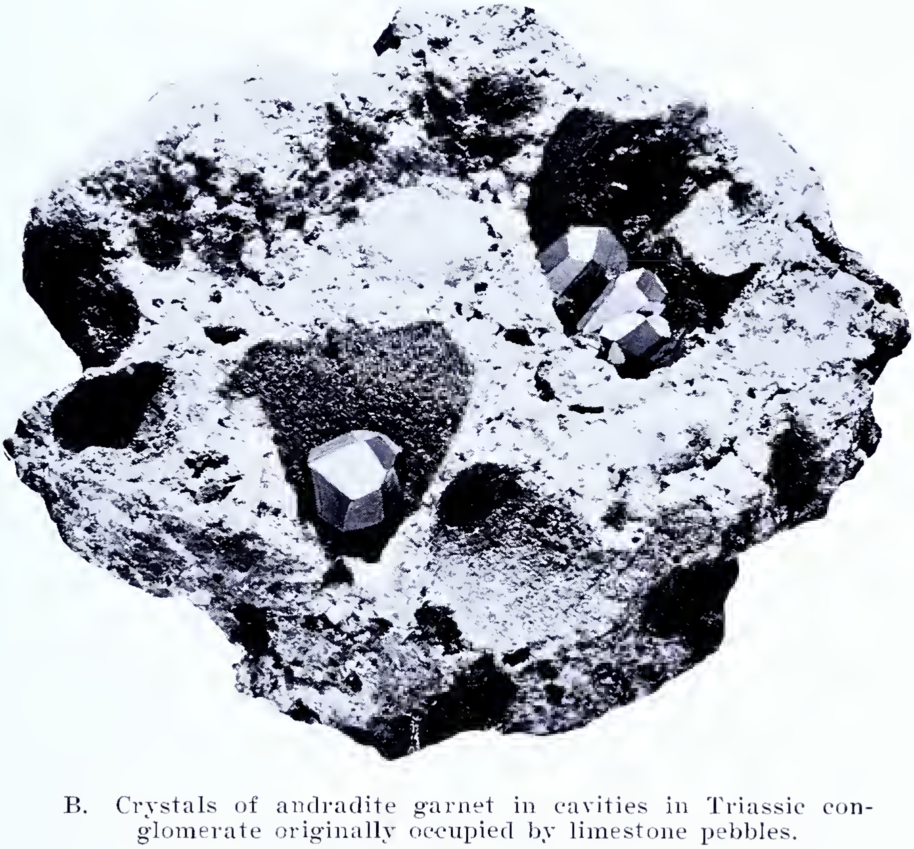
Residue insoluble in dilute acid, 7.30

A thin limestone, probably the same bed as the above and in general strike with it, is exposed in the road cut just north of Strinestown. It is green, 1 to 2 inches thick, interbedded with green sandstone and crumbly red sandstone.



A. Carbonized branch in New Oxford formation.

From dump at Le Crone copper mine. Copper strain has penetrated shrinkage cracks on margins of the fossil wood.



B. Crystals of andradite garnet in cavities in Triassic conglomerate originally occupied by limestone pebbles.

2½ miles east of Frogtown.

A composite section of the New Oxford formation in the Gettysburg area in adjoining Adams County, measured by G. W. Stose,[87] is as follows:

Composite section of New Oxford formation in the Gettysburg quadrangle, Adams County.

	Feet
Chiefly red shale with some soft red sandstone, light-gray to white micaceous sandstone, and thin beds of fine calcareous conglomerate	2,200
Many thick-bedded light-gray to white coarse micaceous sandstones with some conglomerate, interbedded with red shale	500
Red and white sandy shale with a few beds of light-gray to white micaceous sandstone	1,300
Hard light-gray to green thick-bedded granular micaceous sandstone with some fine conglomerate	20-50
Red shale, with numerous markings on bedding planes, some dark-red sandstone	210
Gray to white hard micaceous sandstone	1-5
Red shale	420
Coarse white micaceous sandstone and quartzose conglomerate with some 2-inch pebbles	1-5
Red shale and soft, gray to red micaceous sandstone	980
Hard gray micaceous sandstone with some quartzose conglomerate	1-25
Red shale with beds of soft red micaceous sandstone	460
Red shale	660
Hard conglomerate of large pebbles of rounded white quartz	1-5
Red shale, red and yellow conglomeratic calcareous mudrock, fissile black carbonaceous shale, and thin greenish-gray micaceous sandstone	115
Approximate total thickness	6,900

The following section of the lower part of the formation exposed along the Pennsylvania Railroad on the west bank of Susquehanna River between Yorkhaven and Saginaw was measured by M. H. Bissell, in part interpreted by Stose.

Section of the lower part of the New Oxford formation southeast of Yorkhaven

Yorkhaven Station.	Feet
Hard greenish calcareous and carbonaceous shale, passing upward into arkosic sandstone and red shale. Estimated	540±
Largely concealed. Some arkose and red shale. Estimated	240±
Greenish gray arkose and red shale. Estimated	115±
Red shale	15
Greenish arkose, thin bedded in upper part	27
Red shale, with green bands of nodular calcareous material in lower part and a 3-foot bed of green shale near the middle	12
Greenish and buff-colored highly micaceous arkose with some beds of fine conglomerate. 2-foot bed of conglomerate near base, full of plant remains resembling Equisetae. Irregular bedding, cross-bedding, and wedge shaped layers. Estimated	120±
Concealed. Estimated	650±
Buff-colored arkose, irregularly bedded. Some red shale and greenish sandstone in upper part. Estimated	70±
Red shale	8
Largely concealed. 8-foot bed of gray sandstone. Estimated	200±

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[87] Stose, G. W., op. cit., Fairfield-Gettysburg folio, p. 9, 1929.

Section of the lower part of the New Oxford formation southeast of Yorkhaven—Continued

	Feet
Variable arkose, massive to shaly, pebbly in part. Irregular bedding and cross bedding. Contains large and small calcareous concretions and some conglomerate and a little red shale. Some fine conglomerate beds contain carbonized plant remains and very thin coal films. Estimated	130±
Greenish arkose and coarse gray arkose. Estimated	25±
Coarse arkose. Estimated	25±
Poorly exposed sandstone, arkose, and red shale. Estimated	80±
Concealed. Estimated	200±
Red shale	35±
Gray-green arkose, with erosion channel in shale at base	14
Red shale	11
Gray-green arkose with scattered pebbles	13
Red shale with a little interbedded sandstone	50
Coarse greenish cross-bedded arkose and pebbly beds	25
Red sandy shale	7
Greenish cross-bedded arkose, wavy basal contact	7
Red calcareous shale	10
Irregular bedded arkose	11
Red calcareous shale	8
Thick-bedded coarse, gray to buff-colored friable arkose. Irregular bedding and crossbedding. Estimated	52±
Red shale with a few interbedded sandstones. Variable dip and unconformable base. Estimated	44±
Coarse thick-bedded gray-green arkose, with a little red shale. Some pebble layers follow cross bedding	48
Red shale, in part calcareous	15
Gray arkose	10
Highly calcareous red shale	24
Red sandstone	2
Red shale	5
Vertical strike fault (amount of displacement and thickness of missing beds not determined.)	
Massive hard brown sandstone, with erosion channels in shale at base	14
Red shale	7
Highly calcareous shale, with irregular veins, stringers, and layers of calcareous matter	2
Red shale and red sandstone	3
Largely concealed. Mostly red shale and sandstone. Estimated	250±
Gray-green highly micaceous feldspathic sandstone	20
Conglomerate with gray to buff feldspathic sandstone. Estimated	30±
Buff-colored feldspathic conglomerate. Estimated	16±
Quartzose gray to buff-colored feldspathic conglomerate and interbedded sandstone. Estimated	42±
Red shale	20
Pebbly arkose and conglomerate. Estimated	33±
Concealed. Pebbles indicate conglomerate. Estimated	170±
Coarse conglomerate with subangular pebbles up to 10 inches in size, largely of vein quartz but some of shale, quartzite, and limestone. Estimated	110±
Limestone conglomerate, largely angular fragments of limestone up to 2 inches in size in a matrix of red ferruginous micaceous shale	25
Basal contact with Paleozoic limestone not exposed	3,590±

The top of the New Oxford formation is placed where beds of light-gray arkosic sandstone end and red shale and red sandstones prevail. As previously stated, such a boundary line is more or less variable and arbitrary, and is not at the same stratigraphic horizon throughout the area. The boundary as drawn on the map practically follows a stratigraphic line from the western edge of the county to the Dover road (State highway 74). Here the boundary is arbitrarily shifted southeastward about half a mile. Again, northwest of Zion View another arbitrary shift of the boundary about half a mile to the southeast is necessary, because arkosic beds apparently do not occur so high in the section as they do farther southwest. The strike and dip of the rocks indicate that about 2,340 feet of beds belonging in the New Oxford formation lie stratigraphically above the beds at the top of the measured section at Yorkhaven. These beds, exposed southwest of Yorkhaven, are arkosic sandstone and interbedded red shale, with a few thin interbedded limestones near the top. The total thickness of the formation at this place is therefore about 5,930 feet. In the report on the Middletown quadrangle[88] the thickness was estimated to be 6,000 feet.

Age and correlation.—Only a few fossils have been found in the New Oxford formation in this region and they are all of continental type, harmonizing with the terrestrial origin of the sediments. Small fragments of carbonized plant remains and twigs occur in several of the arkosic beds, and larger pieces of silicified wood have been found in plowed fields in the vicinity of Yorkhaven and also in the same strike near Elizabethtown and Bainbridge on the Lancaster County side of the river. This fossil is identified by Wherry[89] as a conifer—*Araucarioxylon vanartsdaleni.*

Reptilian bones and teeth were reported from strata at the bottom of the shaft of the Le Crone copper prospect, 3 miles southwest of Manchester, by Wanner in 1898. More recently well-preserved teeth and bones of a Parasuchian[90] were collected by R. S. Stable and R. C. Bair from exposures in Little Conewago Creek in Manheim township, northwest of York. A well-preserved tooth of this reptile is on exhibit at the York County Historical Society in York. The presence of this fossil crocodile in the Triassic redbeds indicates that swampy terrestrial conditions existed where these sediments were deposited. A small phyllopod crustacean, *Estheria ovata*, Lea, was collected in a dark gray to black shale near the base of the formation half a mile west of Farmers, and the same fossil occurs at the same horizon east of New Oxford, 1 mile west of the York County line.

These fossils suggest correlation of the New Oxford formation with the Upper Triassic of Europe. This determination by fossils accords with the general age determination of these beds based on their relation to the Paleozoic formations and to late Paleozoic structures.

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[88] Stose, G. W., and Jonas, A. I., op. cit., U. S. G. S., Bull. 840, p. 39, 1933.

[89] Wherry, E. T., Silicified wood from the Triassic of Pennsylvania. Age and correlation of the "New Red" or Newark group in Pennsylvania: Acad. Nat. Sci., Phil. Proc. 64, pp. 366-379, 1912.

[90] Sinclair, W. J., A large Parasuchian from the Triassic of Pennsylvania: Amer. Jour. Sci., vol. 45, pp. 457-462, 1918.

The New Oxford formation was named from New Oxford, Adams County, Pa. The formation has the same general lithologic characters as the Stockton formation, the lower formation of the Newark group in the eastern part of the State, and it is recognized that these two formations are more or less equivalent, but as the Lockatong formation, which overlies the Stockton, thins out near Elverson, Pa., exact equivalence cannot be established.

GETTYSBURG SHALE

Distribution.—The Gettysburg shale lies northwest of the New Oxford formation, and occupies a belt 10 to 12 miles wide that crosses the county from Susquehanna River southwest to its western boundary. The Gettysburg shale is injected by several large bodies of diabase in the form of thick sills connecting with large cross-cutting bodies. The shale and sandstone adjacent to these intrusive rocks have been hardened by metamorphism. These hardened rocks and the diabase are more resistant to erosion than are the unaltered Triassic redbeds, and form high hills and ridges. Similarly a hard thick conglomerate and hard coarse sandstone near the base of the formation make a high ridge, so that the topography of the Gettysburg shale area is much less gentle and more elevated than that of the adjacent New Oxford formation. The northwest boundary of the formation is somewhat irregular, owing to the fact that it is determined by a series of faults along which the Gettysburg shale has been dropped.

Character and thickness.—The Gettysburg shale in York County comprises red shale and sandstone with (1) a thick lenticular zone in which there are numerous beds of hard red pebbly arkosic sandstone and conglomerate, called the Conewago conglomerate member, near the base; (2) a zone in which hard gray and red sandstones and coarse conglomerate predominate, called the Heidlersburg member, near the middle; and (3) quartzose fanglomerate and limestone conglomerate at the top. In the type area, in Adams County, the Gettysburg shale is predominantly a red shale and sandstone with interbedded hard gray to white sandstones in the Heidlersburg member and a coarse fanglomerate, called the Arendtsville fanglomerate lentil, at the top. Conglomerate beds of the Conewago conglomerate member begin to appear southwest of Airy Hill School, at the western boundary of York County. They thicken northeastward, and just beyond Harmony Grove make a ridge 400 feet higher than the lowland that is crossed by the York-Dillsburg road, 2 miles northwest of Dover. Hard conglomerate beds continue to increase in number and thickness northeastward and form Conewago Mountain, a ridge attaining 1,050 feet altitude at its highest point, south and southeast of Andersontown. The conglomerates thin rapidly northeastward and finger into red shale and sandstone, and the high ridge ends in two low spurs northwest of Strinestown. The sandstones of this member are described by Bissell as hard, siliceous, non-feldspathic, in which current bedding is common, and the conglomerate beds contain poorly sorted pebbles and cobbles of red and white sandstone and pinkish quartz, most of which are rounded, but some of the smaller ones are somewhat angular.

The soft red shale and crumbly red sandstone, characteristic of the middle part of the formation, is well shown in the lowland east of Lewisberry, in the area southeast of Yoeumtown, southwest of Wellsville, and near Franklintown. Ripple marks, mud cracks, and rain prints are abundant in some of these beds. Several thin beds of impure limestone interbedded with the red shale were observed by Bissell in the vicinity of Kralltown. In red shale of the formation along the road 1 mile northwest of Kralltown molds of lozenge-shaped glauberite crystals[91] were found by Bissell. This mineral, which is a sodium-calcium sulphate, indicates that the deposits were laid down under arid conditions, the mineral having crystallized on the shore of a desiccated enclosed body of water.

Near the middle of the Gettysburg shale there is a zone in which numerous harder gray arkosic sandstones are interbedded with the redbeds. In the Gettysburg area, in Adams County, this zone is about 4,800 feet thick and was named the Heidlersburg member. It forms a belt of higher land about 1 mile wide where it enters the western side of the county at Bermudian, and extends to the cross-cutting diabase at Mt. Zion Church. It is abruptly cut off by this cross-cutting diabase, but a wider belt of somewhat similar rocks continues north of it, and is mapped as the Heidlersburg member. A belt over 2 miles wide of hard red sandstone and conglomerate trends due north from the diabase to Lisburn and there bends northeastward and then eastward through Frogtown, to the diabase body along the river. Conglomerate beds increase in number and coarseness northward and northeastward in this part of the Heidlersburg member, and some beds of limestone conglomerate occur in it east of Lisburn. A bed of coarse conglomerate, locally containing subangular blocks up to 12 inches in size, makes an east-west ridge half a mile northeast of Frogtown, and a large boulder from the conglomerate in this vicinity was reported by Bissell to contain molds of a brachiopod which were identified by Schuchert as *Meristella lata*, of Oriskany age. This indicates that the streams that brought these boulders into the Triassic basin must have come from the west, for rocks of Oriskany age occur only in that direction, and must have been exposed at the surface at that time. Some of the pebbles in these conglomerates are limestone, and adjacent to the diabase intrusions the limestone pebbles in these conglomerates are generally dissolved by the solutions that accompanied the molten magma, leaving the rock porous and pitted. Many of the cavities in this metamorphosed rock are lined with hematite and garnet (see Pl. 25) and 2½ miles east of Frogtown large well-formed crystals of andradite, an iron-garnet, occur in these cavities.[92] (See Pl. 21 B.)

The Heidlersburg member varies in thickness in the county from about 3,000 feet in the southwestern part to about 4,800 feet southeast of Lisburn. A narrow band of hard coarse red sandstone, similar to that in this part of the Heidlersburg member, makes a low ridge west of Lewisberry which parallels the outcrop of the Heidlersburg member, and, north of Lewisberry, it also swings east and passes through

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[91] Stose, G. W., Glauberite crystal cavities in the Triassic rocks in the vicinity of Gettysburg, Pa.: Am Mineralogist, vol. 1, no. 1, pp. 1-4. Jan., 1919.

[92] Stose, G. W., and Glass, Jewell, Garnet crystals in cavities in metamorphosed Triassic conglomerate in York Co., Pa.: Amer. Mineralogist. vol. 23, pp. 430-435, 1938.

Yocumtown. It is regarded as a minor member of the formation at a lower horizon than the Heidlersburg.

In Adams County a thick fanglomerate of unassorted quartzose cobble in a finer gravel and sand lies at the top of the formation and was called the Arendtsville fanglomerate lentil. It makes high hills covered with rounded cobble and boulders in a red sandy soil. One of these hills, 780 feet in altitude, extends into York County west of Clearspring. Fanglomerate bedrock is seldom exposed, as it is so loosely cemented that it readily disintegrates, and the cobble and pebbles derived from it strew the surface. The fanglomerate marks the closing stage of Triassic sedimentation in the region, and was derived from the erosion of the rocks west of the Triassic basin after the marginal faulting began and the South Mountain mass was partly uplifted.

Northeast of this fanglomerate hill, beds of limestone conglomerate occur along the western edge of the Triassic basin, but their outcrop is not continuous, and they are mapped only where they were observed. Several outcrops of this limestone conglomerate are mapped southwest and north of Dillsburg. The best exposure of the limestone conglomerate is in a quarry at the foot of South Mountain, 1 mile west of Dillsburg. Here the conglomerate is about 50 feet thick. The limestone fragments are heterogeneous in size, shape, and character. Many of the limestone fragments are more crystalline than are the Paleozoic limestones exposed in the region from which the fragments must have been derived, and such crystalline fragments appear to have been marmorized in the process of deposition. The fragments are mostly rounded and of various sizes, some of the larger ones measuring nearly 15 inches across. They are unassorted, and are inclosed in a red sandy calcareous matrix and fine conglomerate. The bedding surface of an interbedded calcareous red sandstone is ripple marked. Some layers of limestone conglomerate are compact and have been polished, and such rock is known as Potomac marble or Calico marble. Another quarry ¾ mile southwest of Dillsburg exposed a similar limestone conglomerate about 10 feet thick, interbedded with red sandstone.

Northwest of Lisburn several beds of limestone conglomerate occur at lower horizons in the Gettysburg and are exposed along the Lisburn road southeast of Oak Grove Church. In the bank of Yellow Breeches Creek a sandstone boulder from one of these conglomerate beds contained a fossil brachiopod, suggesting Oriskany age, similar to the fossiliferous boulder in the Heidlersberg member referred to above.

In the vicinity of Gettysburg,[93] Adams County, the type locality of the Gettysburg shale, its thickness was estimated to be about 16,000 feet, and the three members were estimated to be as follows:

	Feet
Upper member	3200
Heidlersburg member	4800
Lower member	7500
	15,500

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[93] Stose, G. W., op. cit., (Fairfield-Gettysburg folio), p. 10, 1929.

This estimate is for the widest exposure of the formation in Adams County. In the northern part of the Gettysburg quadrangle and in the Carlisle quadrangle and extending into York County, the width of the formation is considerably narrower, owing not to steeper dips of the beds, but to the transgression of the western boundary fault. The thickness in these areas is therefore probably less. In York County the Gettysburg shale is so broken up and displaced by diabase intrusions that the total thickness cannot be accurately determined. An approximate estimate of the aggregate thickness of beds of the formation where the Conewago conglomerate and Heidlersburg members are thickest is as follows:

	Feet
Upper member	1500
Heidlersburg member (maximum)	4800
Middle shaly member	4500
Conewago conglomerate member and beds below (maximum)	7300
Total aggregate thickness	18,100

As previously stated, this aggregate total thickness is probably not present at any particular place because of the lenticular character of certain of the beds and the progressive lapping of higher beds over lower ones northwestward, owing to progressive sinking of the floor of the basin and shifting of the center of deposition in that direction. (See fig. 6.) East of Susquehanna River in Lancaster County the Gettysburg shale was estimated[94] to be 9,000 feet thick.

The Triassic beds all dip northwest, and the deepest part of the basin is believed to be at its western edge, where the beds are down faulted. In the rectangular fault block northwest of Dillsburg, a small area of Triassic sandstone rests on a floor of Paleozoic limestone. This block is west of the main border fault. Similar relations were observed at York Springs, Adams County. It is believed that these beds were the last to be deposited, and overlapped the basin and the boundary fault onto the limestone floor west of the basin.

The Gettysburg shale, as previously stated, is injected by large bodies of diabase. Most of these center around the large mass that forms Roundtop and adjacent high peaks. From this central mass smaller offshoots cut across the bedding, and others are injected between the beds as thick sills. Another cross-cutting body in the northern part of the county is detached from the cenral mass at the surface, but they probably unite at depth. The great central mass, which is 4 or 5 miles wide, cuts across the sedimentary beds almost at right angles. This bevelling of the beds is clearly shown along the south border of the diabase west of Rossville, and again along the north border, northwest of Maytown. The rocks adjacent to these thick diabase intrusions are greatly metamorphosed. Red shales are altered to a hard dense tough purplish-black porcelanite, containing irregular knots of green epidote. Red sandstones are bleached nearly white and are silicified to a hard sandstone, or even to a quartzite, flecked

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[94] Stose, G. W., and Jonas, A. I., op. cit. (Middletown quadrangle), p. 41, 1933.

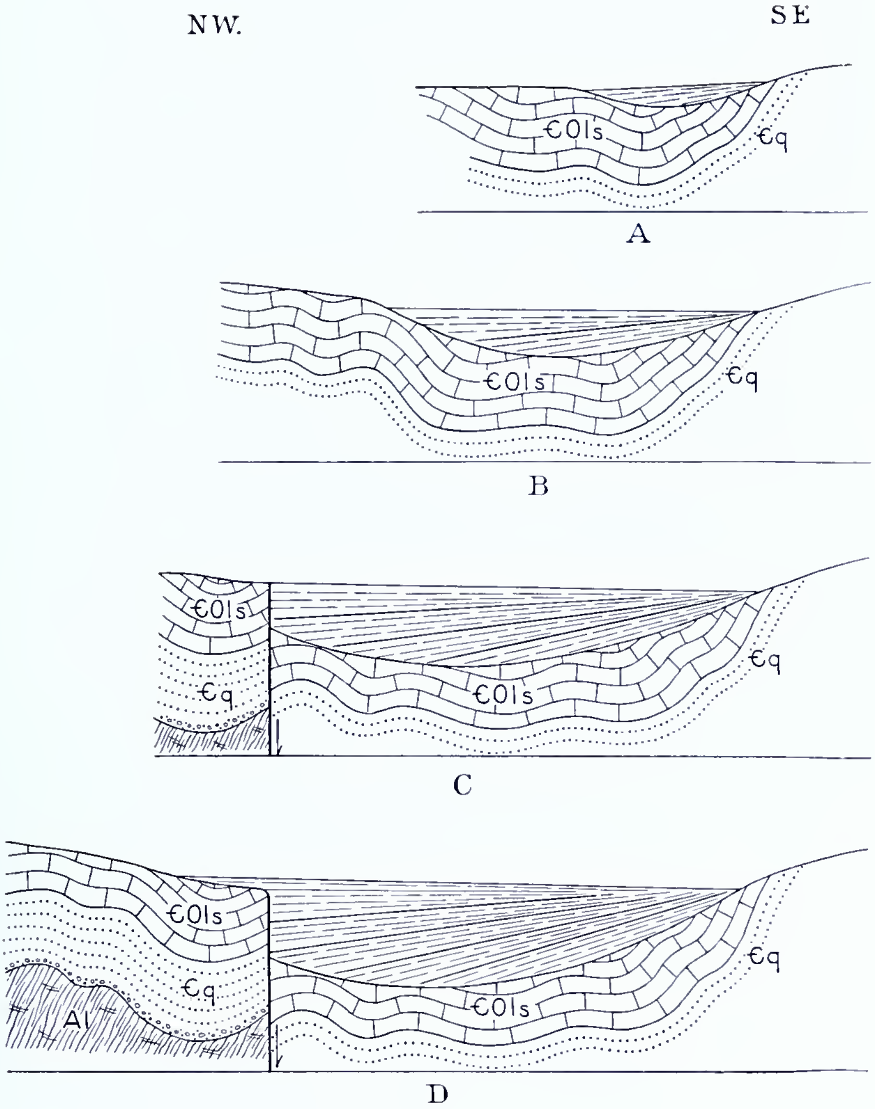

Figure 6. Ideal sections across Triassic basin, illustrating hypothetical mode of progressive deposition of the sediment, with resultant northwest dips. Sediment, derived from the southeast, deposited in basin sinking progressively northwestward. Sinking of floor accompanied by faulting at western edge of basin and further tilting of beds. The last deposits overlap the bounding fault onto the bordering Paleozoic limestone. €Ols, Cambrian and Ordovician limestones; €q, Cambrian quartzite; pre-Cambrian volcanic rocks below.

with white kaolinized feldspar. The description of these metamorphosed sediments is given below. (pp. 130-133.)

Age and correlation.—The Gettysburg shale was named from Gettysburg, Adams County, Pa., where it is typically exposed. Small fossil shells of a phyllopod crustacean that have been identified as *Estheria ovata*, Lea, were collected by the writers in a green shale in the Gettysburg at Middletown, Lancaster County. The same form has been collected from black shale at the base of the New Oxford formation near Farmers, York County, and at several other places to the southwest and northeast in Pennsylvania. Fossil footprints of a dinosaur have been found[95] in red sandstone of the Gettysburg near Yocumtown, and reptilian and fish remains have been collected from equivalent beds farther east in Pennsylvania. Recently some excellent molds of dinosaur footprints (see Plate 22) have been found by Elmer R. Haile in these beds at Trostle quarry on Bermudian Creek near Pondtown Mill, 3 miles east of York Springs, Adams County.[96] The fossils indicate that the formation is of Upper Triassic age. It is lithologically similar to the Brunswick shale, the upper formation of the Newark group in the eastern part of the State, and these two formations are approximately equivalent.

Plant remains and fossil footprints of 3-toed animals were first reported from rocks of this area by Wanner,[97] who collected what he regarded as algae from red sandstones near Goldsboro. Later 6 species of plants collected near Yorkhaven were identified and named by Ehrenfeld.[98] Wanner and Fontaine[99] later described and figured 31 species of plants, collected by Wanner chiefly in the cut of the Northern Central (Pennsylvania) Railroad east of Yorkhaven, and some from Little Conewago Creek west of Manchester. These fossils embrace ferns, equisetums, cycads, ginkgos, conifers, and grasses. (See Pl. 23.) Wanner commented, in connection with the footprints, that all tracks lead in the same direction.

Triassic igneous rocks

DIABASE

Distribution.—The Triassic sediments of York County have been intruded by diabase in the form of sills, cross-cutting bodies, and dikes. Two thick sheets or sills, the Yorkhaven and Gettysburg, occur in the county. The Yorkhaven sill crosses western Lancaster County in the direction of the strike of the sediments that it intrudes, and its southwest end enters York County at Yorkhaven. From that place the diabase extends northwestward as a cross-cutting body through Newberrytown and Wickersham Hill, and gradually narrows in that direction until, north of Lewisberry, it is not exposed at the surface. This

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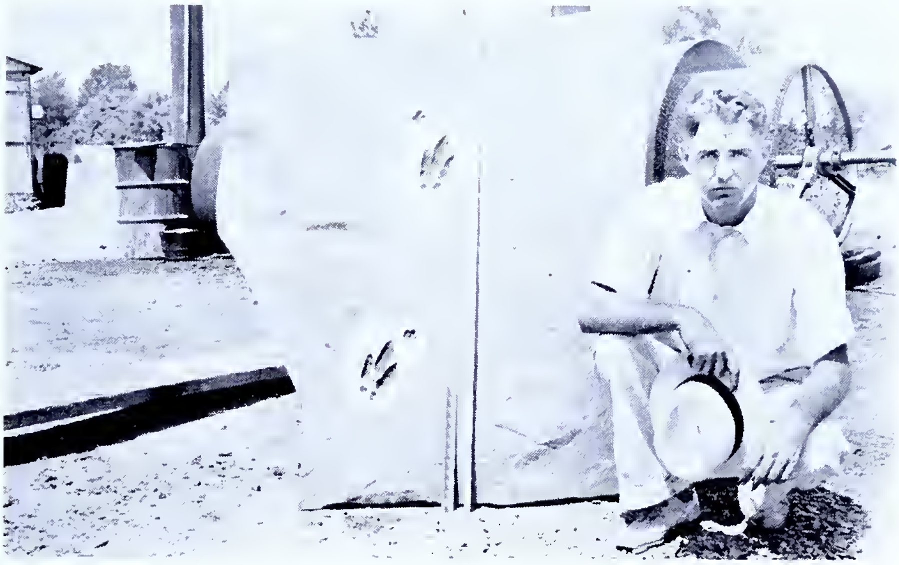
[95] Hickok, Wm. O., and Willard, Bradford, Dinosaur foot tracks near Yocumtown, York County, Pa.: Penn. Acad. Sci., vol. VII, pp. 55-58, 1933.

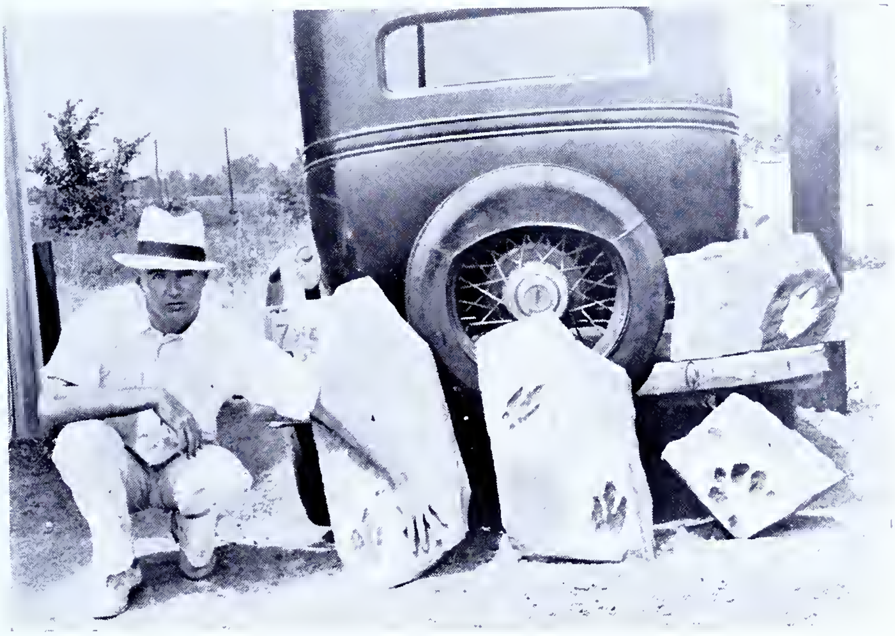
[96] Cleaves, A. B., Pennsylvania Dept. of Int. Aff. Monthly Bull, vol. 4, no. 3, pp. 12-15, Aug. 1937, and no 4, pp. 8-11, Sept. 1937.

[97] Wanner, Atreus, The discovery of fossil tracks, algae, etc. in the Triassic of York County, Pa.: Pa. Geol. Survey Ann. Rept. for 1887, pp. 21-35, 1889.

[98] Ehrenfeld, Frederick, A study of the igneous rocks at Yorkhaven and Stony Brook, Pa. and their accompanying formations. Thesis at Univ. of Pa., pp. 1-24, 1898.

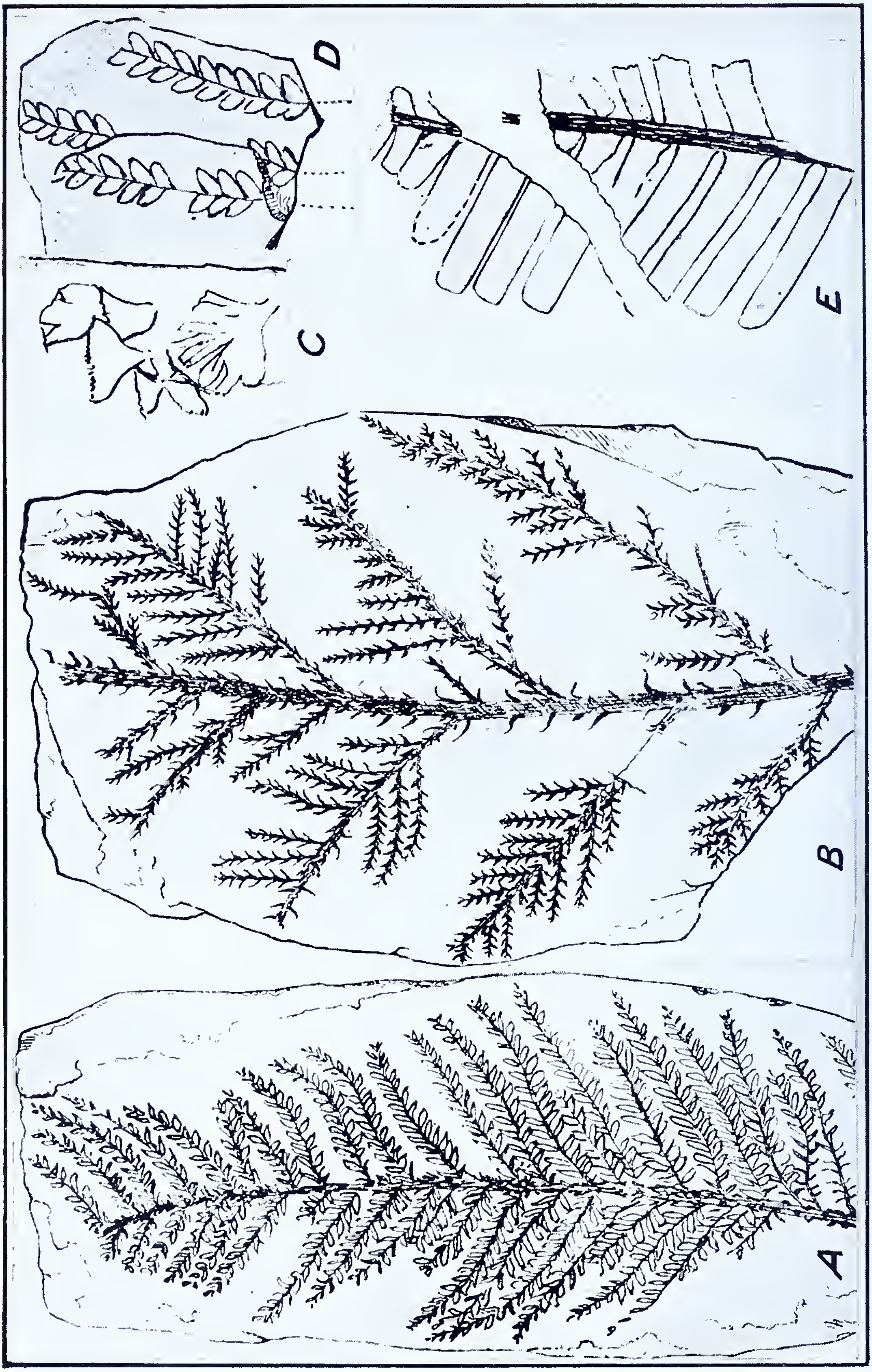
[99] Wanner, Atreus, and Fontaine, Wm. M., Triassic flora of York Co., Pa.: U. S. Geol, Surv. 20th Ann. Rept., pt. 2, pp. 233-254 and plates 22-34, 1900.





Dinosaur foot prints preserved in Triassic sandstone.
Trostle quarry, near York Springs, Adams County. Foot prints of *Anchisauripus sillimani*, a carnivorous dinosaur. Collected by Elmer R. Haile and owned by J. L. Thomas.

PLATE 23



Fossil plants from the Gettysburg shale collected and figured by A. Wanner.

A. Conifer. Palissya diffusa (Emm.) Fontaine.
B. Conifer. Cheirolepsis muensteri (Schenk) Schimp.
C. Ginko. Baiera muensteriana (Presl) Herr?
D. Fern. Acrostichites microphyllus Fontain?
E. Cycad. Pterophyllum inaequale Fontain.

cross-cutting body, or thick dike, apparently thins rapidly at its upper limit, and the width of its outcrop depends on the depth of erosion. One mile southeast of Newberrytown the dike is cut by a normal fault with upthrow on the west, and the dike is therefore eroded deeper and is wider west of the fault. A similar expansion in width occurs west of another normal fault at Newberrytown. From here westward the width gradually narrows as the top of the dike declines until, north of Lewisberry, the dike lies below the surface of erosion and does not outcrop for about 1/4 mile, but is probably continuous underground with the dike to the northwest. North of this low point the dike swells considerably in width in the deep valley of the headwaters of Fishing Creek, owing in part to its deeper dissection. Northeast of Lewisberry two thin sills extend eastward from the dike between the sedimentary beds. The dike continues northward nearly to the edge of the Triassic basin. Two small diabase masses near Oak Grove Church, in Cumberland County, seem to be offshoots of the diabase near the border of the basin, but the connection is not exposed at the surface.

Northwest of Frogtown the dike swings sharply to the east and then southeastward in a direction nearly parallel to the southern arm of the intrusion, and there parallels the York County side of Susquehanna River from Marsh Run to Middletown Ferry. Here it passes eastward and forms the north end of Hill Island and Fall Island, and continues northeastward as a concordant sill into Lancaster County, passing through Swatara Hill.[1]

The Gettysburg sill, which enters York County from Adams County a mile south of Bermudian Creek, extends 12 miles northeastward parallel to the strike of the Gettysburg shale which it intrudes. The southeast side of the sill, together with the underlying baked shale, make a strip of high country called Straight Hill, lying on the northwest side of Conewago Creek. Two miles southeast of Lewisberry the sill joins a large cross-cutting diabase mass 4 to 5 miles wide that extends northwestward and cuts off the sedimentary beds of the Gettysburg shale, including the Heidlersburg member, almost at right angles to their strike. In the vicinity of Maytown the diabase body is covered by a roof of baked shale.

This wide area of diabase divides at the west into two narrower cross-cutting bodies, the northern one passing through Mt. Pleasant and the southern one extending west from Blair Hill. These dikes in turn pass into small sills near the western margin of the Triassic basin. The northern sill extends from Grantham southwestward to Dillsburg, and the southern sill ends 3 miles southwest of Dillsburg. The diabase mass that lies near and parallel to the Triassic boundary fault southwest of Dillsburg may be a southwestward continuation of the northern sill. A small irregular-shaped area of diabase that lies east of Dillsburg is apparently the source of large bodies of magnetite ore which have been extensively mined near Dillsburg. A large elliptical area of diabase south of the main diabase body and west of Wellsville also has numerous magnetite deposits on its borders, where small mines have been located. Another large elliptical body of diabase is exposed southwest of Franklintown.

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[1] Stose, G. W., and Jonas, A. I., op. cit. (Middletown quadrangle), U. S. Geol. Surv. Bull. 840, pp. 41-42, 1933.

The sediments adjacent to the diabase intrusions are indurated and metamorphosed, and form a border of altered rock around the diabase areas. Indurated sediments that overlie the diabase and form its roof interrupt its outcrop. One long narrow area east of Wellsville that separates the main Gettysburg sill into two parts extends from a point 1 mile east of Kralltown to north of Maytown, where it expands northwestward, roughly following the trend of the cross-cutting underlying diabase. Smaller inliers of the baked sediments of the roof lie to the west and south of Mount Airy. The outlying areas of diabase west of Wellsville and near Franklintown are entirely surrounded by baked shale and these areas of baked shale are continuous with the baked shale on the borders of the adjacent large diabase mass, indicating that the diabase in the two outlying areas is connected at shallow depth with the main mass. The occurrence of small dikes and projections of diabase which extend south from the main mass in the direction of the outlying diabase areas is a further indication of this connection. Two areas of baked shale west of Yorkhaven overlie and form the roof of the Yorkhaven sill.

Both the diabase and indurated sediments are more resistant and are eroded more slowly than the unaltered softer shales and sandstone of the Triassic, and therefore form hills and ridges that are the highest land in the county. Roundtop, which attains almost 1,400 feet altitude, is a conspicuous conical peak that is visible in the landscape for many miles. Adjoining hills underlain by diabase are Johns Knob (1,100′), Flat Mountain (1,260′), and Nells Hill (1,240′).

The diabase in the Yorkhaven and Gettysburg sills dips northwest with the inclosing strata. In Lancaster County[2] the thickness of the sill near Lawn, where the dip is 30° NW., was estimated at 1,600 feet. In the Gettysburg area its general thickness is about 1,800 feet.

Dikes.—Several narrow diabase dikes cross York County. The trend of these dikes is for the most part a little west of south. The Stonybrook dike enters York County half a mile west of the mouth of Codorus Creek, where it forms Haldeman Riffles in Susquehanna River. It crosses York County, passing through Seitzland in the southern part of the county, and extends into Maryland. It makes a conspicuous ridge that is strewn with diabase boulders where it cuts the Conestoga limestone. The dike is well exposed in a cut of the Pennsylvania Railroad north of Stonybrook, where it is about 50 feet wide and is vertical, cutting sharply across limestone beds that dip 30 ° SE. This dike is paralleled to the west by other thinner dikes of lesser extent that cut both the Triassic sedimentary rocks and the Paleozoic rocks and older crystalline rocks. One dike splits into two southwest of Rockville and both branches extend into Maryland.

A dike with a trend S.40°E. crosses the Triassic rocks and enters the Paleozoic limestones near Botts. Two normal faults nearly parallel to this dike offset the Triassic sedimentary rocks near Farmers. Dikes on the western border of York County near Hanover, and in Adams

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[2] Stose, G. W., and Jonas, A. I., idem, p. 41.

County to the west, have a direction S.10° to 20°E. The direction of these dikes is controlled by tension cracks, which in places are faults and have offset the Triassic sediments. Faults south of Abbottstown that offset the basal beds of the New Oxford formation trend S.10°E. and are parallel to the dikes west of Hanover. East of Bowmandale and northeast of Lisburn three dikes follow fault fractures that trend S.30°E. and offset the northwest edge of the down-dropped Triassic sedimentary rocks. A dike east of Safe Harbor crosses into York County and extends southwestward into Maryland. A dike 1½ miles long cuts the Peters Creek quartzite north of Slate Hill. It seems evident that the dikes and the normal faults which they follow, or parallel, represent major lines of Triassic fractures that cut across older structural lines which are nearly at right angles to them.

Several dikes originate in the Yorkhaven sill. The Stonybrook dike, previously described, leaves the sill 4 miles east of Yorkhaven. Another dike leaves the sill 1 mile west of Yorkhaven, and a third dike, which begins 3 miles west of Yorkhaven, passes ¾ mile west of Strinestown and then extends southwestward for a total distance of 8 miles. Northwest of Zion View 1¾ miles it splits into two branches for a short distance and both dikes are exposed in a road cut. The easterly dike, about 10 feet wide, has recrystallized a two-inch bed of dolomite east of the contact to a coarse-grained black dolomitic marble showing curved cleavage faces. East of Dillsburg numerous short dikes are associated with larger intrusive diabase masses.

General relations and mode of intrusion.—Diabase sills form extensive intrusive bodies in the northwestern part of the Triassic area of Pennsylvania. (See fig. 7.) The larger sills are the Haycock, Ziegler, Saint Peters, Yorkhaven, and Gettysburg. The diabase intrudes the sedimentary rocks as concordant sills, parallel to the strike of these rocks for long distances, and then cuts across the strike at right angles as cross-cutting bodies. In most cases these transgressive bodies extend to the northwestern edge of the Triassic basin, where they are terminated by the faults at the boundary of the Triassic sedimentary rocks. Each of these intrusive bodies, therefore, has the form of a great trough bounded on the southeast ends by the sills and on their sides by the cross-cutting bodies. The Yorkhaven and Gettysburg sills lie in the northwest part of the Triassic sedimentary rocks of York County.

The probable method of intrusion of the Gettysburg sill was discussed by Stose,[3] and a similar method of intrusion was described for the Yorkhaven sill[4] that crosses the Susquehanna River 10 miles north of York. The vents of the diabase are believed to lie near the northwestern side of the basin along faults where most of the progressive sinking occurred during Triassic deposition. The rising magma entered between the beds southeast of the vents as sills and broke through the beds to the northwest in the form of cross-cutting bodies. The magma from these main vents not only spread into the sills, but

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[3] Stose, G. W., Triassic igneous rocks in the vicinity of Gettysburg, Pa.: Geol. Soc. America. Bull., vol. 27, pp. 625-630, 1916

————————, Op. Cit., Fairfield-Gettysburg Folio, pp. 11-12, 1929.

[4] Stose, G. W., and Jonas, A. I., op. cit. (Middletown quadrangle), U. S. G. S. Bull. 840, pp. 41-43. 1933.

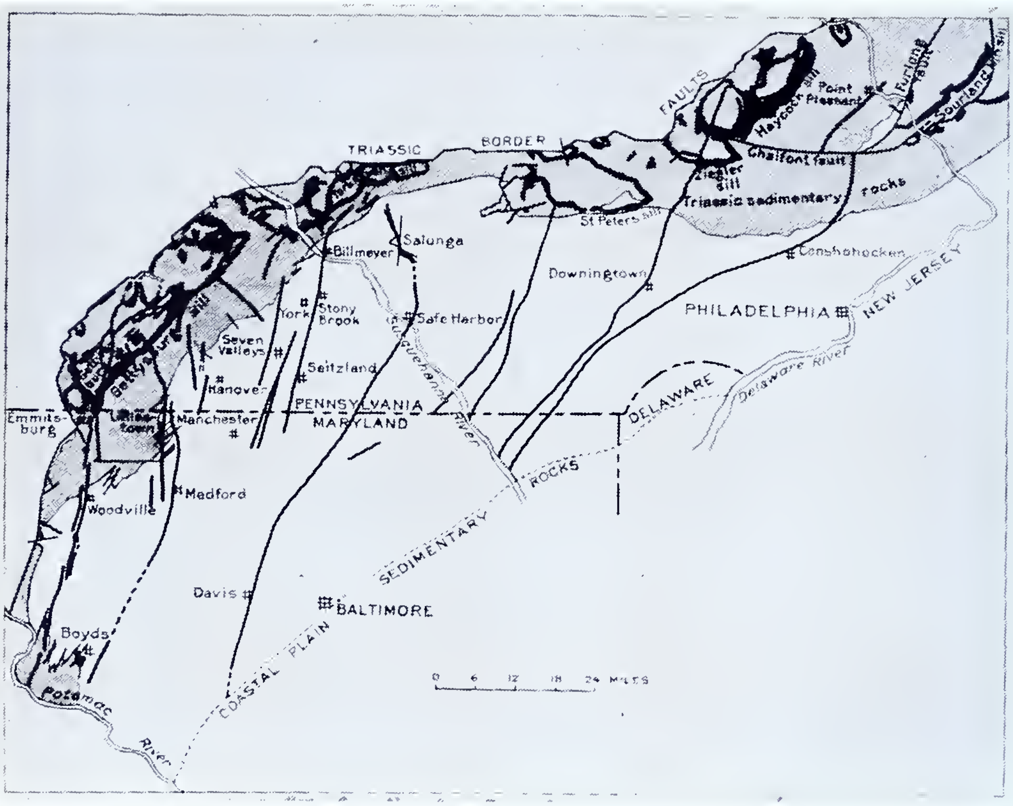

Figure 7. Map of southeastern Pennsylvania and Maryland, showing distribution of the Triassic sedimentary rocks (dense pattern) and diabase intrusions (black). Shows also diabase dikes cutting the older rocks.

extended still farther southeastward as dikes in fracture systems in the Triassic sedimentary rocks and into the older underlying rocks southeast of the limits of the basin of Triassic sedimentation. It is possible that some of these dikes may have been feeders to larger bodies of diabase in Triassic sedimentary rocks now removed by erosion in the area southeast of the present outcrop of the Triassic rocks, but there is no known evidence in support of such a view. In fact, most of them are so narrow that the magma would be too chilled in passing through the narrow fissures to flow any distance beyond.

Character of the rock.—The diabase of the dikes is a fine-to-medium-grained dark-gray to black rock with a typically diabasic texture. The chief constituents are laths of grayish-green plagoclase, andesine or labradorite, usually without terminal planes, and interstitial green augite. Other minerals that can be seen only in thin section are magnetite, apatite, and a little quartz. The sills and larger cross-cutting bodies have fine-grained borders in which the rock resembles the diabase in the dikes, while the centers of the intrusions are medium- to coarse-grained diabase. Augite exceeds feldspar in amount in the fine-grained diabase. The coarse-grained variety contains the same minerals as the finer grained, but in the coarse-grained diabase the proportion of feldspar in respect to the amount of ferromagnesian constituents is greater. The coarse-grained diabase is a granular rock composed of coarse laths of white or gray plagioclase with black pyroxene, magnetite, and scanty quartz. When the rock weathers by reason of the decomposition of feldspar and pyroxene, it first bleaches to a gray or light-buff color at the surface and along the joint planes, and tends to flake off in thin shells parallel to these surfaces. The flaking caused by chemical decomposition is aided by daily and seasonal temperature changes of the rock. The result of weathering is the formation of rounded boulders and bosses (see Pl. 24 B) in a buff-colored granular sand, which finally weathers to red clay. Many of the smaller diabase boulders have a thick crust of residual red clay. Much of the country underlain by the diabase is rocky, hence left in woods, and flowering shrubs, such as dogwood, spice bush, and red bud, grow in abundance on the margins of the woods. In spring the white, yellow, and magenta flowers respectively of these trees stand out as a mass of color against the dark diabose masses among which they grow.

Petrography.—The fine and coarse-grained gray to grayish-white diabase shows, under the microscope, a typical diabasic texture. The rock consists of elongated lath-shaped crystals of plagioclase (labradorite or sodic labradorite or andesine) lying in all directions, with pyroxene, largely augite, occupying interstitial spaces between the plagioclase laths, and usually contains magnetite. The lighter-colored, coarse-grained diabase may contain small quantities of quartz, biotite, and titanite. Olivene-bearing diabase occurs in the Gettysburg area.

Diabase differentiates.—Near the top of the sills in York County there are six areas of coarse-grained, pink diabase, or diabase pegmatite. The rock is a quartz-bearing diabase, composed largely of pink feldspar and green hornblende, in which the feldspar exceeds hornblende in amount and which contains micropegmatite visible in thin section. The locations of the six areas are just west of Yorkhaven, 1 mile east of Wellsville, at Mount Pleasant Schoolhouse, in Johns Knob, east of Stevenstown and in the Gettysburg sill at the western border of the county. (See Pl. 1.)

In the eastern area, just west of Yorkhaven, none of the pink diabase[5] was found in place. It occurs near the top of the Yorkhaven sill adjacent to a remnant of the baked sandstone cover of the sheet. The feldspar in this area is microcline and albite*, occurring in automorphic laths much clouded by sericitic alteration and colored pink by hematite dust.

Two small areas of pink diabase occur near the upper contacts of the diabase 1 mile east of Wellsville and at Mount Pleasant Schoolhouse. At both places only weathered fragments were observed. The rock in the occurrence near Wellsville, which is in the Gettysburg sill, is the coarsest grained of any seen in the region. It is made up of pink feldspar and green hornblende prisms ½ inch in length; hornblende prisms attain 1 inch in length.

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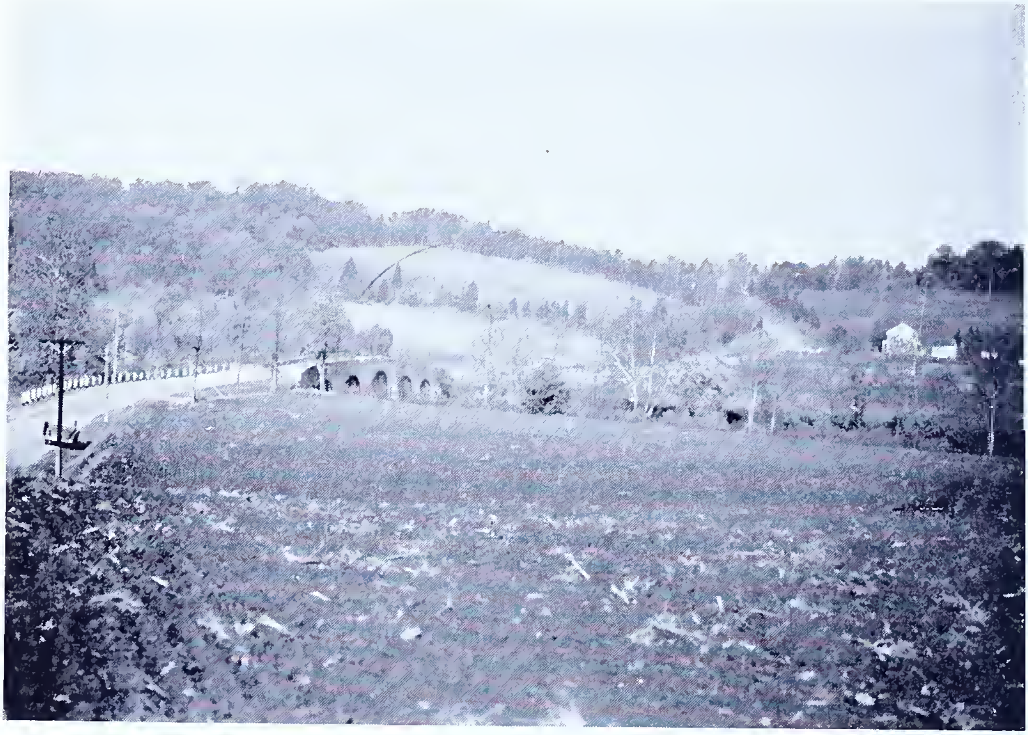
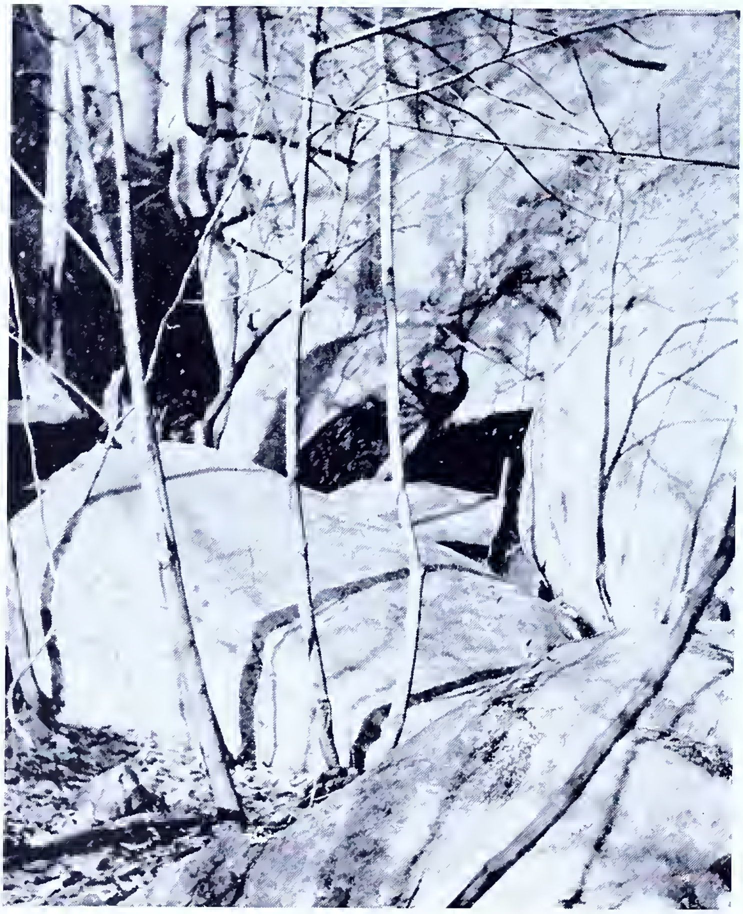
[5] Stose, G. W., and Jonas, A. I., op. cit., U. S. G. S Bull. 840, pp. 45-46, 1933.

* The feldspars of the pink diabase were determined by J. J. Glass of the U. S Geological Survey.



A. Bridge, built of Triassic sandstone, over Conewago Creek on State Highway 74.

Looking north to hills underlain by the Gettysburg sill.



B. Large tumbled masses of diabase that form the "Governor's stable," 1 mile east of Falmouth, Lancaster County.

The Johns Knob area of diabase, which is also part of the Gettysburg sill, is surrounded, except on the north, by baked Triassic sedimentary rocks that are part of the roof of the sill west of Maytown and form Ramsey Hill. In Johns Knob the diabase is coarse to medium grained and is composed of pink feldspar and green hornblende. Under the microscope the pink feldspars are largely albite, with andesine of the composition An41-Ab59. They lie in a matrix of micropegmatite. Hypersthene and green hornblende are both present, and hornblende is in part altered to chlorite. Inclusions of allanite surrounded by marked radioactive haloes occur in the hornblende. Apatite, magnetite, and ilmenite are present in small amounts.

The largest area of diabase differentiate extends from Stevenstown eastward for 1½ miles along the northwest border of the diabase body, and is 1 mile wide along the highway where it extends from Uno southeastward to south of Nells Hill. It forms the western spur of Nells Hill and the northeastern foot of Blair Hill, and on the south is surrounded by, and grades down into, typical diabase which forms Nells Hill. The lower part of the differentiate, near the typical gray diabase at a point 1 mile southeast of Uno, is medium-grained hornblende diabase with pale pink feldspar. To the northwest and higher in the sheet, the grain size of the minerals and the proportion of pink feldspar in the rock increases. The northwestern part of the area is a fine-grained rock largely made up of pink feldspar with fine hornblende needles. A thin section of the rock from the lower part of the pink diabase shows that the feldspar is andesine to labradorite (Ab50-An50) which occurs in laths surrounded by micropegmatite. This feldspar is very nearly of the composition of the normal diabase below it. A thin section from pink diabase north of Nells Hill, near the upper border of the diabase body, shows, under the microscope, a preponderance of albite over oligoclase, and a much altered plagioclase, probably albite. The feldspars are in well-formed laths, sericitized and coated with hematite dust. Microgranitic and myrmekitic intergrowths of quartz and altered plagioclase enclose the laths. Green hornblende, which formed later than the feldspar, penetrates it and encloses magnetite grains irregularly moulded or grouped in clusters. The hornblende is in part altered to chlorite. Apatite crystals are in large part included in the feldspars, and quartz grains occur in small amount.

In the western part of the county, where a partial section of the Gettysburg sill is exposed along State Highway 194, coarse-grained grayish-white normal diabase forms the center of the sheet and pink diabase lies above it. The coarsest layer is about 10 feet thick, and grades upward into medium-grained pink diabase. The upper part of the differentiate is finer grained, with hornblende in excess of feldspar, and contains areas 1 inch long of dark olive-green hornblende crystals. It is cut by coarse-grained aplite. At the top of the Gettysburg sill there is, as elsewhere, a thin layer of typical fine-grained, dark-gray diabase at the chilled contact. Bissell reports that nearby, along Bermudian Creek, a fine-grained variety of the light-colored diabase may be seen cutting typical dark diabase in narrow dikes and veins not more than 1 to 2 inches wide.

The medium-grained, pale-pink pegmatitic diabase near Highway 194 contains sodic oligoclase (Ab90-An10), highly sericitized. Hornblende, which has in part replaced the feldspar, is present in two varieties, one brownish-green and the other blue-green. Epidote grains are arranged in clusters with the hornblende and titanite as an abundant constituent. The specimen does not contain micropegmatite, observed in the samples from other localities. Differentiates of diabase have been noted also to the southwest in the Gettysburg sill near Gettysburg, and at Saint Peters, Chester County. The differentiation resulted in a portion that is richer in feldspars, and probably more sodic in composition, as well as rich in mineralizers, which in many places escaped into the adjoining sedimentary rocks. The top of the sill, which is described as a more "basic" fine-grained diabase, is the chilled contact layer that represents the original magma and that solidified before the differentiation took place.

In the York County areas the pink, coarse-grained, more-sodic diabase in every case lies near the top of the diabase body and has a cover of fine-grained normal diabase. The lower part of the coarse-grained pink diabase contains a calcic feldspar with a composition similar to the plagioclase of normal diabase. Higher in the sill, the pink feldspar becomes more sodic in composition and more abundant. In the uppermost layers, which lie just beneath the fine-grained upper border of the sills the feldspar is albite. Quartz is present throughout the pink diabase and the abundance of iron is seen in the magnetite and in the fine hematite dust which is disseminated throughout the feldspars and which gives them their pink color. It seems evident, therefore, that the coarse-grained pink hornblende diabase occurring in the upper part of the diabase bodies in York County represents a gravitative differentiation of the diabase magma that took place in the upper parts of the intrusive bodies at places where greater fluidity obtained, and where the residual magma, relatively rich in silica, soda, and potassa, had risen from lower levels of the magma to its top.

Metamorphism of wall rock.—On the upper and lower borders of the sills and at the contacts of the cross-cutting bodies the adjacent red shale and sandstone are altered to a dense bluish-black porcelanite or hornfels, and the reddish to gray sandstones are altered to white or green quartzite. The altered shale and sandstone have been recrystallized and contain new minerals developed by the metamorphism of the diabase. These hard, baked rocks grade through a narrow belt of less-metamorphosed purple shale and sandstone into the normal red rocks of the Triassic. This altered border is usually ¼ to ½ mile in width, but, where the dip of the sill is less than 30°, it is wider. (See Pl. 1.) In the southwest corner of the county, where the Gettysburg sill and the enclosing sedimentary rocks dip 40° NW., the outcrop of the metamorphosed contact is only ¼ of a mile wide.

The red and pinkish sandstones of the Triassic sediments are bleached to a grayish-white color, and are cemented in part to a quartzite. In places epidote and hematite occur in the quartzite, and southwest of Maytown the joints of the epidotic quartzite are coated with epidote and pink pegmatite. A mile west of Yorkhaven, near the southward bend of Conewago Creek, the diabase has metamorphosed pebbly sandstone beds of the Gettysburg shale to an epidotic quartzite in which the form of the original pebbles is preserved. Nodules of specular hematite also have been introduced. Epidotic quartzite also occurs in contact with a curving dike-like offshoot at the lower part of the Yorkhaven sill at this place, and it is probable that the mineralizing solutions proceeded along a small fissure occupied by the dike.

Metamorphism of the red shale by the diabase produces an aphanitic bluish-black hornfels. In the process, the red ferric oxide of the shale is dioxidized in the presence of organic matter or some other reducing agent. In places the blue hornfels is spotted with fine dark shot-like nodules and such a rock has been called spilosite. A good example of spotted hornfels occurs in the baked shale above the Gettysburg sill exposed on State Highway 194 in the western part of the county. The groundmass is formed of felty sericite, fine quartz, and feldspar grains, and minute granules of iron oxide. The dark nodules have an ill-defined hexagonal form and are composed of felty sericite and magnetite dust. It is assumed that the sericite replaced cordierite, although no remnants of that mineral was found.[6] The hornfels contains green hornblende with irregular outlines, and small cavities filled with crystals of the zeolite, heulandite, with epidote prisms on the borders.

Some of the siliceous shales are baked to a dense green hornfels containing rounded nodules of epidote and chlorite which weather as knots[7] on the surface. The green color of the rock is produced by fine epidote grains. Such a rock usually contains also fine-grained sericite, quartz, and felspar, and may contain fibrous hornblende.

Small brownish garnets in layers parallel to the bedding, occur in a green hornfels west of Yorkhaven. In thin section the garnets show zoning and are a yellowish brown in the center and a lighter yellow on the border. They are the lime-iron garnet, andradite, formed by the contact metamorphism of the diabase. The Heidlersburg member of the Gettysburg shale northwest of Yocumtown in places is composed of beds of red coarse conglomerate containing limestone pebbles as well as pebbles of quartz and feldspar, and a finer-grained arkosic sandstone. On the borders of the intrusive diabase these beds are altered to a grayish-white color, and the limestone pebbles in the conglomerate are either dissolved, leaving cavities, or are silicified to a gray calcareous sandstone. Garnet has been found in the solution cavities of the conglomerate 2 miles north of Yocumtown and ½ mile west of Frogtown. The garnets are crystals of the lime-garnet andradite, which coat the cavities in a thin layer, and are associated with hematite. (See Pl. 25.) Crystals 1 to 2 centimeters in diameter were found at the locality north of Yocumtown. (See Pl. 21 B.) The occurrence and mineralogy of these gar-

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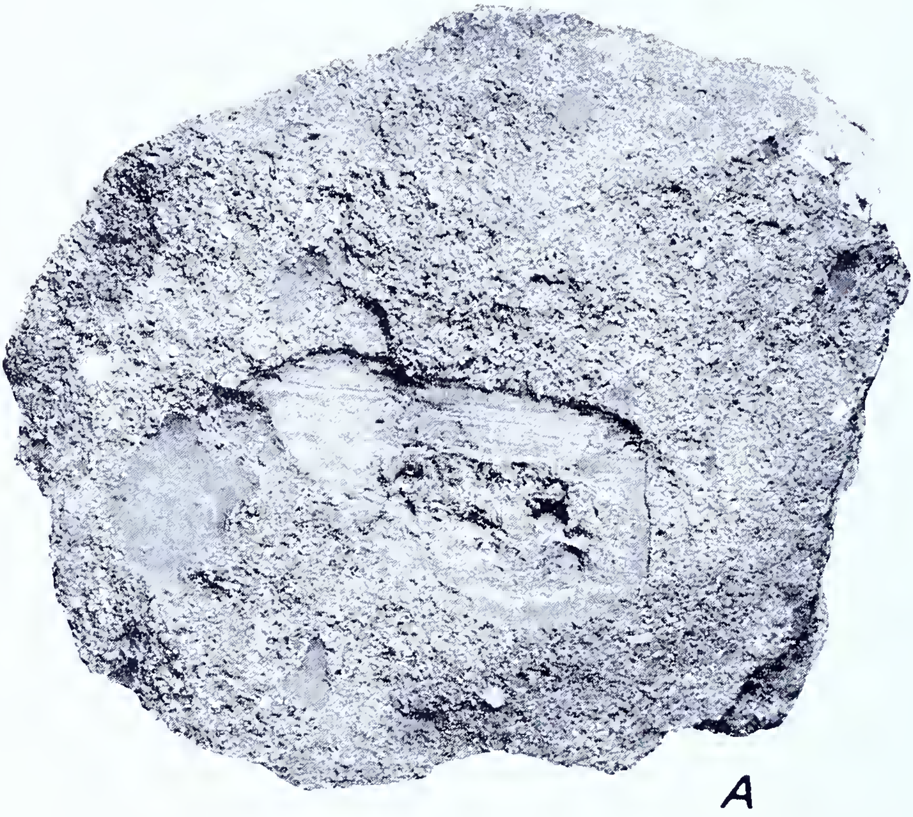
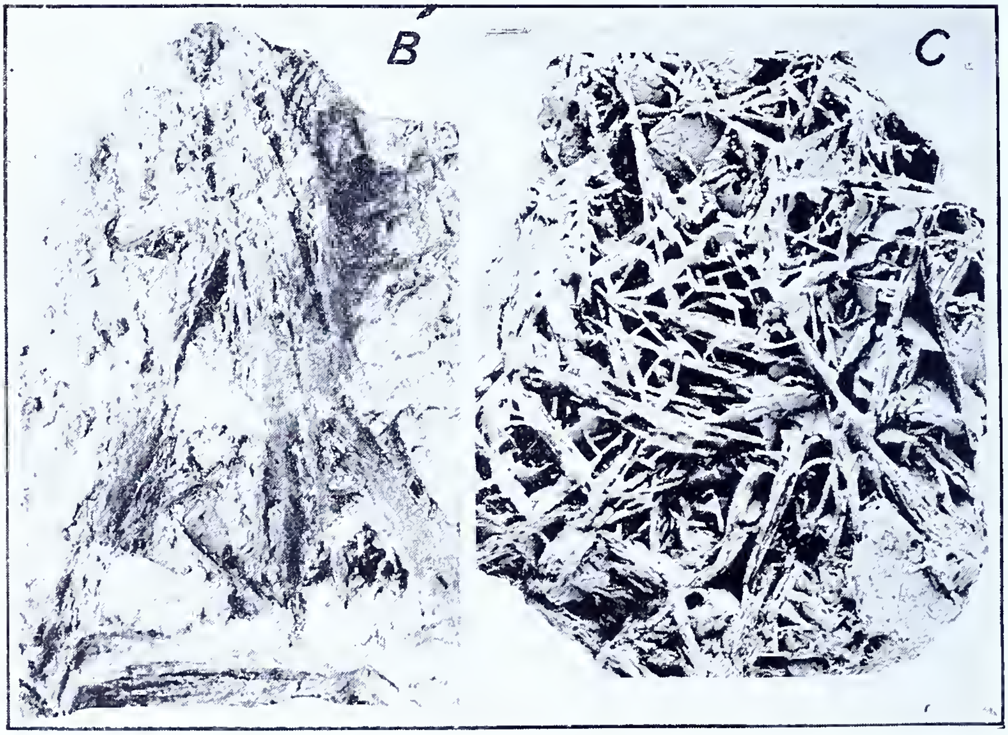
[6] Lewis, J. V., Petrography of the Newark igneous rocks of New Jersey, N. J. Ann. Rept. pt. 4, pp. 138, 143, pl. 30, pl. 31, fig. 3, pl. 32, figs. 1-5, 1907.

[7] Stose, G. W., op. cit., (Fairfield-Gettysburg folio), illustrations 2, pl. 22, 1929.



A. Limestone pebble in Triassic conglomerate partly replaced by hematite and silica. Erney, Pa.



B and C. Hematite replacing limestone pebbles. x3. 2 miles north of Yocumtown.

nets have been described in a recent publication.[8] These garnets are zoned and contain an outer zone of birefracting garnet surrounding a completely isotropic central area. The garnet is associated with magnetite, and it is evident that the magnetite-rich solutions that accompanied or followed the intrusion of the diabase and were the source of the iron, combined with lime from Paleozoic limestone or limestone pebbles of the Triassic sedimentary rocks to form the lime-iron garnet, andradite. Small crystals of yellowish-green garnet were found also near Grantham in York County in brecciated Paleozoic limestone near the border fault on the northwestern side of the Triassic basin. The garnets were associated with calcite and with magnetite that was formerly mined at that place. Similar garnets, associated with epidote, pyroxene, and magnetite, were found near Rosegarden 1 mile west of Grantham. Garnet, pyrite, and magnetite is described by Harder[9] as occurring in the baked Triassic sandstone and shale in the magnetite mines at Dillsburg.

TERTIARY DEPOSITS

HIGH TERRACE GRAVELS

Deposits at three levels.—Remnants of river gravels on several high terraces are preserved in York County.[10] The highest gravel deposits are on a narrow bench parallel to the Susquehanna River on the north side of the Hellam Hills, at an altitude of 720 to 740 feet. The gravel is composed largely of rounded pebbles and cobbles of milky-white quartz in a white sand matrix, in places cemented by iron oxide and the pebbles rust stained. The gravel has been observed for a distance of only a quarter of a mile, but white sand, in part cemented by iron oxide, extends over most of the surface of the terrace for more than a mile. Cobbles derived from the terrace gravel are strewn over the slope below.

A lower terrace at an altitude of 620 feet lies half a mile to the north on the slope of the Hellam Hills, and therefore nearer the river. Pebbles of red sandstone (Juniata?), fossiliferous quartzite (Oriskany?), and much white quartz occur in this gravel. The bench on which the gravel occurs is over a mile long. The gravel is best displayed in the cleared fields 1 mile east of the mouth of Codorus Creek. Some of the gravel is cemented by iron oxide into a hard ferruginous conglomerate, fragments of which are found on slopes below. Scattered round pebbles and cobbles and sand at this level have been found also on the quartzite hills 2 miles southeast of Wrightsville. The 600 to 640-foot terrace is well developed along the river bluff from Long Level to Shenks Ferry, and a few pebbles were found on this plain at Bethel Church.

Still lower terrace gravels, at an altitude of about 500 feet, occur at several places along the river bluff. The terrace represented by these deposits is well defined at and south of Chickies Rock in Lancaster County, on which only scattered pebbles and cobbles are found. Similar scattered pebbles and sand at this level occur in York County on the hills south of Roundtop, southeast of Saginaw, and in the vicinity of Shenks Ferry. In Lancaster County, across the river, they are reported at this level southeast of Safe Harbor and at several places southeast of Holtwood, and at Black Baron near the Maryland line.

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[8] Stose, G. W., and Glass, Jewell. J., op. cit. (Garnet Crystals), Am. Min., vol. 23, pp. 430-435, 1938.

[9] Harder, E. C., Structure and origin of magnetite deposits near Dillsburg, York Co., Pa.: Econ. Geol., vol. 1, p. 619, 1910.

[10] Stose, G. W., High gravels of Susquehanna River above Columbia, Pa.: Geol. Soc. America Bull., vol. 39, pp. 1073-1075, 1928; Stose, G. W., and Jonas, A. I., op. cit. (Middletown quadrangle), Bull. 840, U. S. G. S., pp. 46-49, 1933.

Origin and age.—These gravel deposits are close to and parallel the Susquehanna River, and are undoubtedly remnants of gravel laid down by the river when it flowed at these levels. At the time each of these deposits was formed the flood plain of the river stood at that level, and all the surrounding country was above that level, although much of it has since been worn away. The highest gravel was deposited first and is the oldest; the river then cut its channel about 100 feet deeper when the second gravel was deposited; again the river channel was cut about 100 feet deeper when the third gravel was deposited. Each gravel bench marks a period of prolonged erosion, cutting of a broad flat flood plain, and deposition of gravel on the plain.

The lowest of these high gravel deposits, at 500 feet altitude, is believed to represent the Bryn Mawr gravel. Small remnants of gravel at about this level have been found on the high bluffs in the narrow gorge of the river, as described above, and these connect with extensive gravel-covered uplands at an altitude of 470 feet at the fall line near the mouth of the river at Woodlawn, Md.[11] This gravel is believed to be of Pliocene age. It rests on a flat surface that represents a long period of erosion and peneplanation, and the peneplain formed at this time appears to be the same as the 500-foot terrace around Wrightsville and Columbia and the upland plain on the Ordovician rocks in the limestone valley northeast of Harrisburg at an altitude of 560 to 580 feet, there called the Harrisburg peneplain.

The next higher gravel deposit, at 600 to 620 feet, is considerably older and represents an earlier Tertiary period of peneplanation, possibly Miocene. Remnants of terraces at this level are also found on the brink of the river gorge below East Prospect. The highest gravel, at 720 to 740 feet, or 500 feet above the present level of the river, is much older and represents deposition of river gravel possibly in Eocene time.

QUARTERNARY DEPOSITS

LOWER TERRACE GRAVELS

Deposits of gravel are preserved on terraces along the river at four lower levels but they are best developed north of the river in Lancaster County. The highest of these is poorly preserved in York County. It is represented by the gravel-covered terrace at 420 feet altitude north of Mt. Wolf, and a small remnant of gravel at 440 feet near Shenks Ferry. This same terrace is present across the river from Shenks Ferry, but gravel was not found on it. Gravel is also present on a bench at 400 feet altitude 1 mile north of Peach Bottom and on the hill 1 mile east of Slate Hill in the southern part of the county. Broad flat uplands at this level extend from the State line southward on both sides of the river, and 4 miles northwest of Havre de Grace and across the river south of Woodlawn this terrace is covered with gravel.

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[11] Stose, G. W., Is the Bryn Mawr peneplain a warped surface?: Am. Jour. Sci., 5th ser., vol. 19, pp. 178-179, 1930.

The next lower gravel lies on a bench that is 340 feet in altitude at Columbia, 360 feet at Marietta and Billmeyer, 360 to 380 feet north of Falmouth, and 380 feet at Middletown. Remnants of this gravel cap the hills or lie on benches along the river and are in most places of small extent. In York County gravel on terraces at 380-400 feet altitude south and southeast of Yorkhaven is of this stage, and small remnants occur north of Slab and near Peach Bottom at 340 feet elevation.

The next lower terrace gravel is on a bench that is 300 feet above sea level at Columbia and Marietta, 320 feet at Bainbridge, and 340 feet from Falmouth to Middletown. Remnants of this terrace gravel are of much larger extent, being in places 1 mile wide and several miles long. In York County, at the mouth of Yellow Breeches Creek, terrace gravel at 340-360 feet altitude covers a wide flat that was formerly a meander of the Susquehanna River at this stage. New Cumberland and Newmarket and the Harrisburg airport are located on its flat surface, which is nearly 1½ miles wide at its widest part and 4 miles long. Gravel occurs on a small terrace at 280 feet altitude in the river gorge north of York Furnace.

The lowest terrace is only 20 to 40 feet above the river and merges with the present flood plain and is not separately mapped. This terrace has very large boulders on its surface and, although it is narrow, it is well marked in places, even in the gorge of the river, as for instance, at Shenks Ferry.

These lower terrace gravels contain pebbles and cobbles of granite, other igneous rocks, metamorphic rocks, various quartzites, and chert. Some of these rocks are of types not found in the upper drainage basin of the Susquehanna, and were evidently brought into the basin by glaciers. Boulders 5 to 10 feet in largest dimensions are plentiful in the gravel on the two lower terraces and must have been ice borne because of their size. Some of the boulders bear glacial striae. The terraces are tentatively correlated by the writer with the four terraces in the Coastal Plain at the mouth of the river, as follows: The terrace gravel at 400 to 440 feet altitude may represent the Brandywine terrace; that at 340 to 380 feet may be correlated with the Coharie formation; that at 300 to 340 feet with the Sunderland formation; and the lower terrace gravel with the Wicomico formation. The Talbot formation cannot be traced above Holtwood.

On Conewago Creek terrace gravel 20-60 feet above the stream has been observed on flat-topped spurs in meanders and has been mapped. On Codorus Creek terrace gravel 60-80 feet above the stream was observed at only one place, south of West York. Lower terrace gravels occur in many of the meanders of these streams, but they have not been mapped. On Yellow Breeches Creek gravel has been mapped on the more prominent terraces in meanders at 40-60 feet above the stream.

ALLUVIUM

Alluvium is present in the flood plains of all the larger streams in the county, but has been mapped only along Susquehanna River, Conewago Creek, and in places on Codorus Creek. The widest flood plain on the west side of Susquehanna River is southeast of Yorkhaven, where it forms an island between two mouths of Little Conewago Creek and the river. Most of the low islands are covered with alluvium, but they are in Lancaster County. A wide strip of lowland covered with alluvium lies southeast of Bridgeville. Fine particles of coal, washed into streams from the culm piles in the anthracite field in the northern part of the State, are mixed with the sand now being deposited by the river, and the bars in the bottom of the river below Columbia and in the vicinity of Harrisburg are dredged from boats and the coal reclaimed. The coal is separated from the sand by screens on the boats and deposited in great piles on the shore.

Alluvium has been mapped along the upper part of Conewago Creek where terrace gravels are also well developed. On Codorus Creek alluvium has been mapped only on an unusually wide flood plain below the junction of South Branch and East Branch. Another wide area of alluvium borders the stream in the lowland south of West York and into York, but is omitted from the map as it would conceal the intricate bedrock geology. Alluvium-covered flood plains occur along these streams between stretches where the creek flows in steep-sided gorges with little or no alluvium. The flood-plain soil is generally very fertile and is cultivated in most places.

Alluvium and soil cover the wide, flat, limestone lowlands of the York-Wrightsville valley and the lowlands at Spring Grove, Nashville, Hanover, and Penn Grove, and in the Jefferson syncline, but are not shown on the map. The soil of these lowlands, derived largely from the products of the weathering of limestone, is exceptionally fertile and highly cultivated, and rock outcrops are scarce.

GEOLOGIC STRUCTURE

The structure in the Triassic rocks and that in the Paleozoic rocks and older rocks is entirely different because the Paleozoic and pre-Cambrian rocks were folded and faulted before Triassic time. The Triassic rocks have suffered no folding, but they have been tilted and broken into blocks by normal faults. The structures in the pre-Triassic rocks and those in the Triassic rocks, therefore will be described separately. The rocks south of the Martic overthrust are crystalline schists probably of pre-Cambrian age, and their structure will likewise be described separately.

PALEOZOIC AND OLDER STRUCTURES

General statement and age of the structures

The Paleozoic rocks of York County were deposited in nearly horizontal layers on pre-Cambrian rocks in the southeastern part of the Appalachian region. During the deposition of these beds in Cambrian and Ordovician times, minor uplifts of the sea bottom occurred, but such movements did not greatly disturb the parallelism of the strata.

During the Lower Cambrian epoch the sea bottom around Mine Ridge, Lancaster County, and to the southwestward in York County, was rising and the Cambrian formations there deposited are thinner than in the area to the north. After Lower Cambrian time, also near Mine Ridge and in the region of the Hanover, York, and Lancaster valleys, there was uplift and erosion so that the Conestoga limestone of probable Ordovician age overlaps the Lower Cambrian formations.

In northwestern York County, early in Trenton time, there was local uplift of the South Mountain anticline, resulting in erosion and bevelling of the upturned beds, so that southwest of Shepherdstown the Martinsburg shale and the underlying Leesport limestone, of Trenton age, overlap the bevelled edges of beds down to the Elbrook limestone. (See plate 1 and fig. 4.) The chief break in the otherwise continuous sedimentation occurred in the Trenton epoch, at which time uplift was so great in the eastern and southern parts of the region that the Chambersburg and Stones River limestones were either not deposited or they were eroded after deposition.

Although the Paleozoic rocks were deposited in nearly horizontal layers, they are now tilted at various angles and are closely folded. The pre-Cambrian rocks of the area have also been affected by this deformation, but as layering in those rocks is not so well developed as in the Paleozoic sedimentary rocks, the later folding cannot be readily distinguished from earlier structures produced in the rocks during organic movements in pre-Cambrian time.

It is known, from broad studies of the Appalachian region, that near the close of the Carboniferous period the rocks of the Appalachian region were greatly compressed and were folded into elongated arches, or anticlines, and troughs, or synclines, whose axes trend northeastward. In the southeastern part of the folded belt, including York County, the axial planes of most of these folds are inclined and dip southeast and the folds therefore are overturned to the northwest. Many of such folds are closely appressed and are broken by faults, and the rocks on the southeast side of such breaks have been overthrust northwestward and broken also by normal faults. The pre-Triassic rocks in northwestern York County have been less closely folded, but they also are broken by thrust faults.

The youngest Paleozoic rocks in York County are of Ordovician age, but Devonian and Carboniferous rocks in Perry County, not 10 miles northwest of York County, were folded during late Carboniferous time along axial trends parallel to the folds in York County. It is concluded, therefore, that the Paleozoic and underlying pre-Cambrian rocks of York County were folded and compressed at the same time as those of the Appalachian region in general, during the epoch of mountain making, which is called the Appalachian Revolution.

Rocks north of the Martic overthrust

The major folds in the Paleozoic rocks and pre-Cambrian rocks north of the Martic overthrust are the South Mountain anticlinorium, Hellam Hills anticlinorium, Pigeon Hills anticlinorium, Wrightsville syncline, Mt. Pisgah, Holtz, and Kraft Mill anticlines, and East Prospect and Jefferson synclines. These are broken by the Glades, Highmount, Gnatstown, and Stoner overthrusts and many minor faults. The structure of the Paleozoic rocks south of the Triassic areas is described in much greater detail in a forth-coming report on the Hanover-York District, to be published by the U. S. Geological Survey.

SOUTH MOUNTAIN ANTICLINORIUM

Only a small part of the northeast-plunging end of the South Mountain anticlinorium enters the northwest corner of York County. The compound character of the anticlinorium is well shown in the adjoining part of Cumberland County and in Franklin County, farther southwest. Pre-Cambrian volcanic rocks form the core of most of the folds, and they are flanked on both sides by Cambrian quartzites. Three anticlines and two synclines form the northeast-plunging end of the anticlinorium. Stone Head anticline and Dogwood Hollow syncline lie largely in York County. Whiskey Spring anticline, lying northwest of these structures, is largely in Cumberland County, but its northeast end enters York County. Mountain Creek syncline and Mount Holly anticline lie in Cumberland County beyond the limits of the map. (Fig. 8.) The quartzites in Whiskey Spring anticline form the ridges that end in the high peak 2 miles northwest of Dillsburg, just west of the county line. Ledges of the quartzites are seldom exposed in this area, hence the dip of the rocks can seldom be determined, but the rocks appear to form a nearly symmetrical anticlinal fold. They are cut off, however, on the south side along Dogwood Hollow by a normal fault of probable Triassic age, which drops the Cambrian dolomite in the Dogwood Hollow syncline and cuts across the bevelled edges of the Antietam and Montalto quartzites. The quartzites that form Long Mountain, just west of the county line, are the southwestern part of the Dogwood Hollow syncline west of the normal fault. A minor anticline on the north flank of the Whiskey Spring anticline makes a sharp jog in the Antietam quartzite ridge north of White Rocks.

The quartzites in the Stone Head anticline form Stone Head and the ridge to the northeast. This also appears to be a nearly symmetrical anticline of Antietam quartzite enclosing a core of Montalto quartzite. These are cut off from the underlying Weverton quartzite and Loudoun formation to the west by another normal fault at Stone Head. The Antietam quartzite and Tomstown dolomite on the southeast limb of the anticline are cut off by the Triassic border fault. South of Stone Head the pre-Cambrian rocks have been overthrust onto the anticline, and the fault passes southwestward into the pre-Cambrian rocks in Adams County. The South Mountain anticlinorium is part of the larger anticlinal structure that extends from the South Mountains in York County southwestward into Maryland, where the area between the Blue Ridge and Catoctin Mountain has been called the Catoctin Mountain-Blue Ridge anticlinorium.

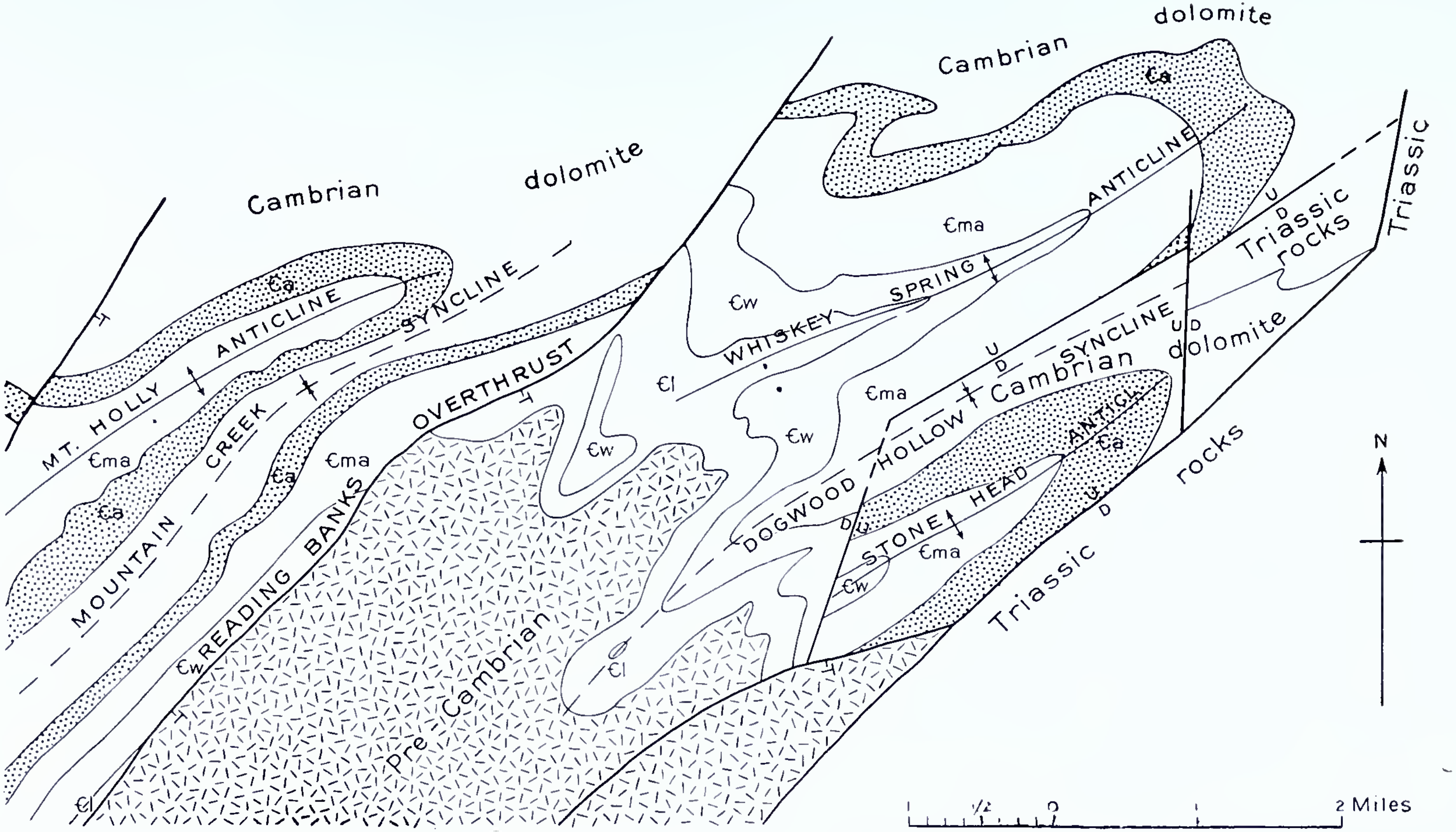


Figure 8. Sketch geologic map showing major structural axes in South Mountain in York County and adjacent parts of Cumberland County. Ꞓa, Antietam quartzite; Ꞓma, Montalto quartzite; Ꞓw, Weverton quartzite; Ꞓl, Loudoun formation.

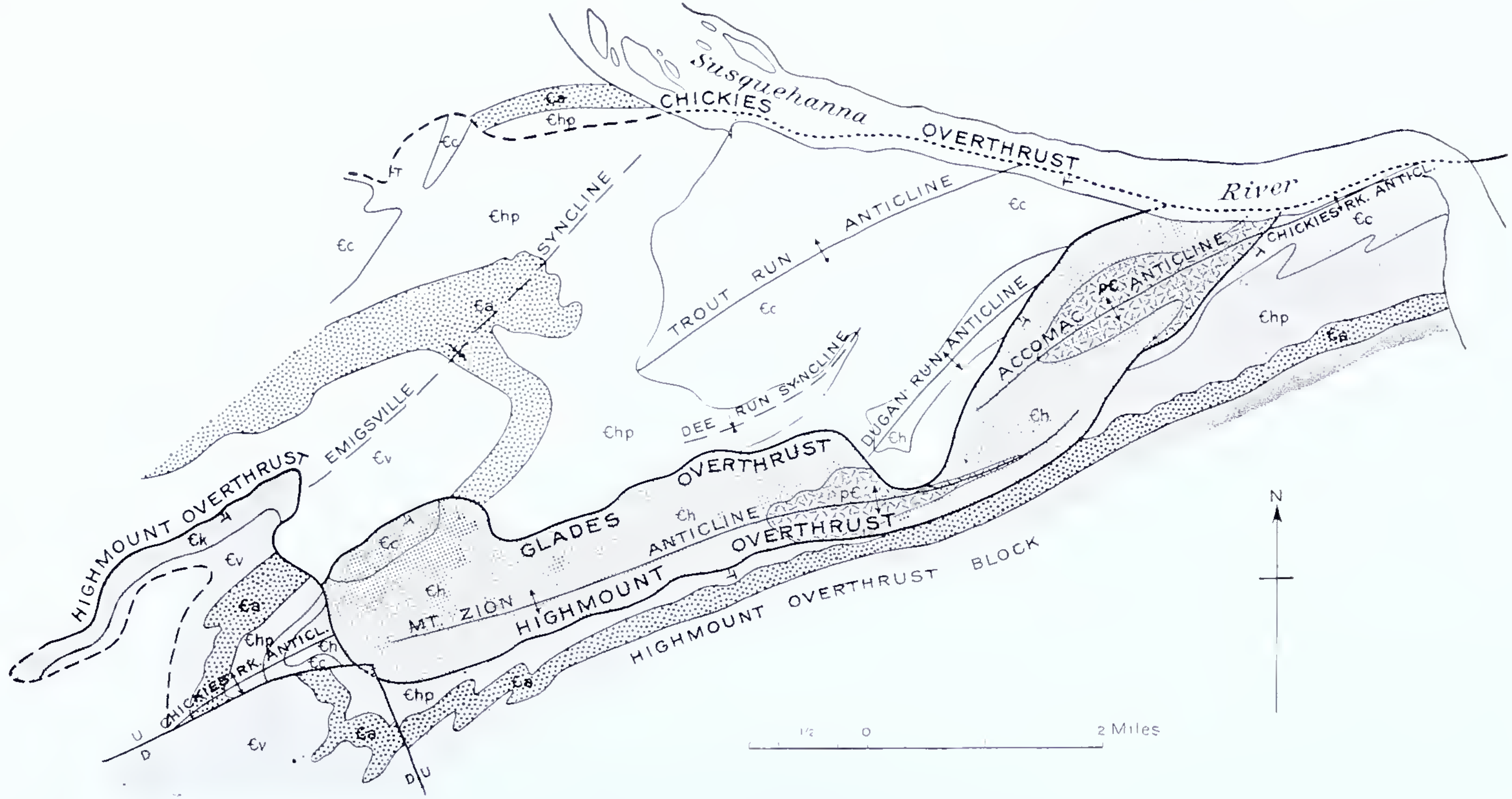
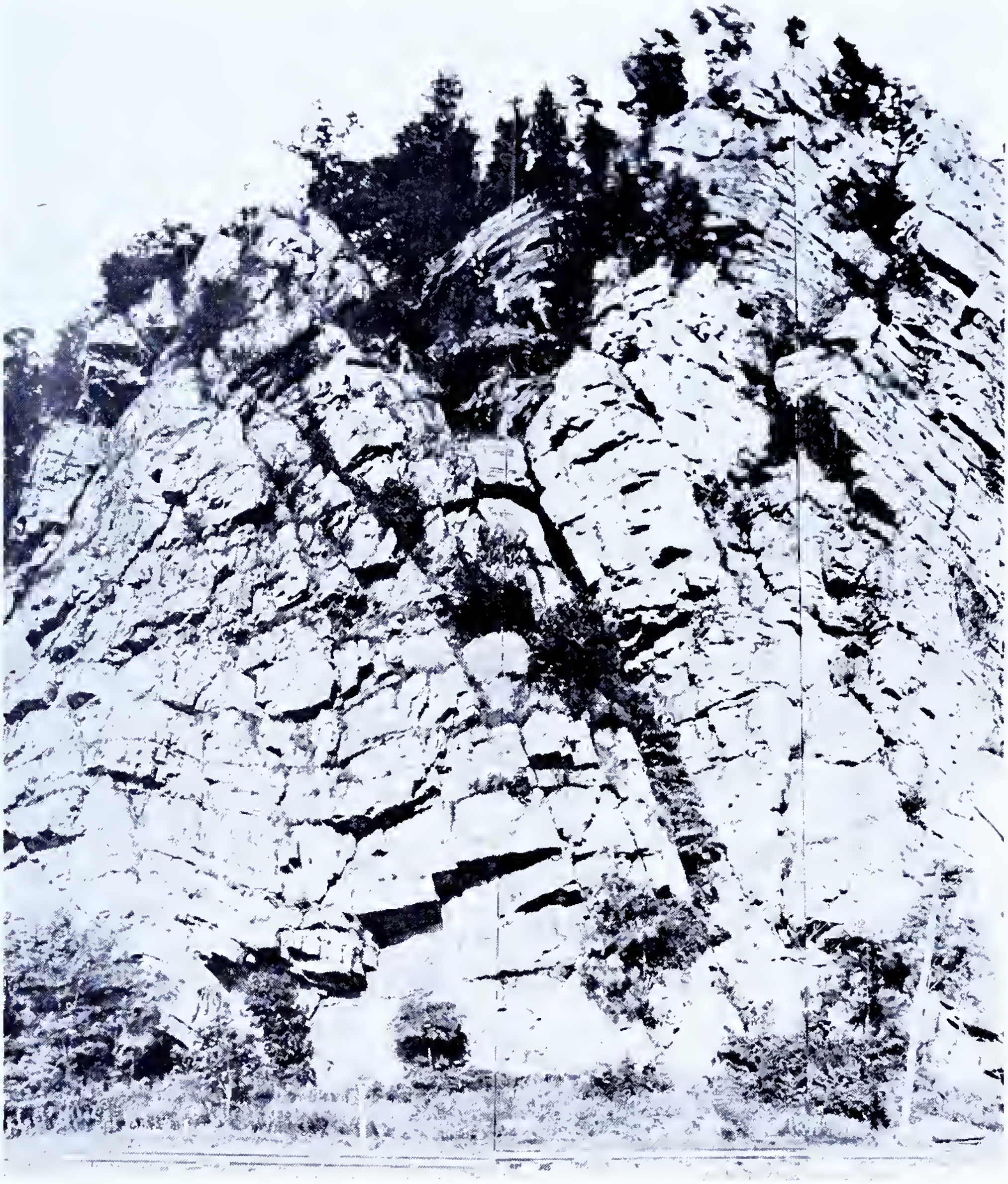


Figure 9. Sketch geologic map showing major structural axes in the Hellam Hills. Light halftone, Glades overthrust block; dense halftone, Highmount overthrust block; Ꞓk, Kinzers formation; Ꞓv, Vintage dolomite; Ꞓa, Antietam quartzite; Ꞓhp, Harpers phyllite; Ꞓc, Chickies quartzite; Ꞓh, Hellam conglomerate member; pꞒ, pre-Cambrian volcanic rocks.



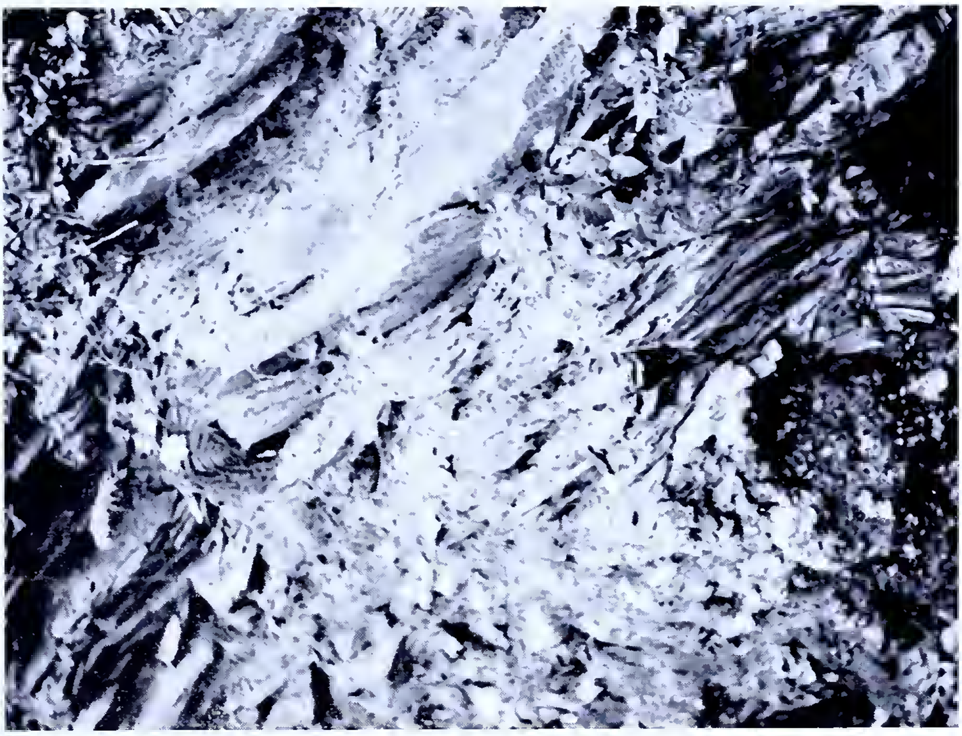
Chickies Rock, Lancaster County, across the river from Hellam Point.
Anticline of Chickies quartzite. (Photograph by C. D. Walcott.)

HELLAM HILLS ANTICLINORIUM

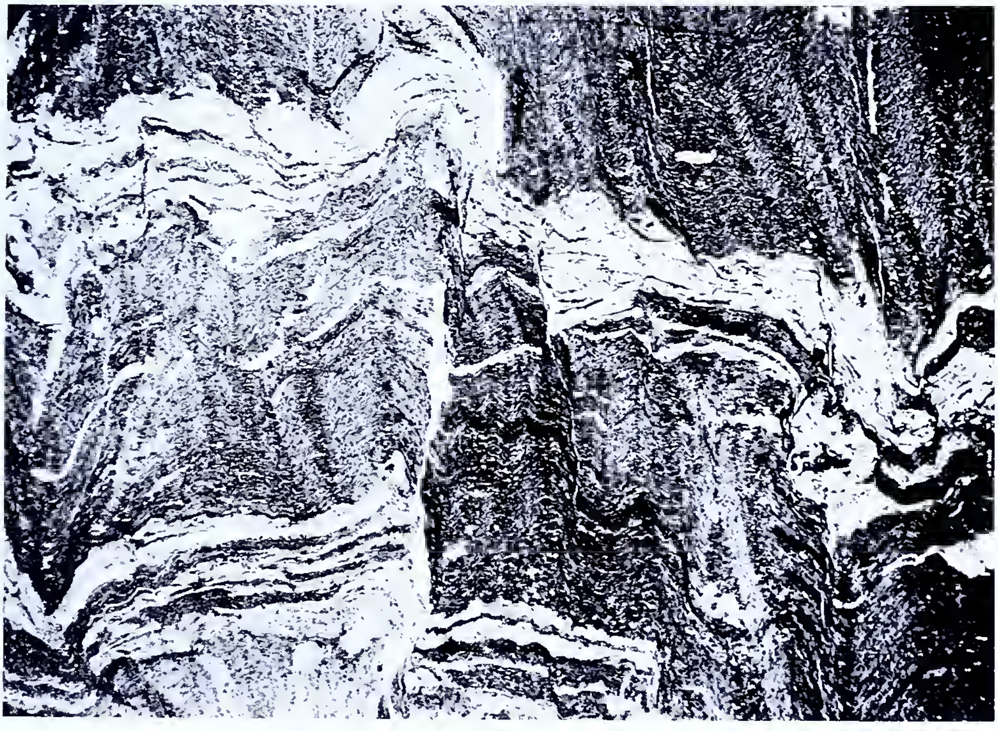
The Hellam Hills anticlinorium is composed of four anticlines—the Mount Zion, Accomac, Chickies Rock, Dugan Run, and Trout Run, with minor synclines between them. (See fig. 9.) All these folds pitch westward, and the northern anticline, Trout Run, pitches abruptly and passes into the Emigsville syncline. The axes of these folds strike northeast and are cut off diagonally at the river by the Chickies overthrust, which follows the east-west course of the river from Chickies rock westward to the mouth of Codorus Creek. Both the Mount Zion and Accomac anticlines expose a core of pre-Cambrian volcanic rocks, which are overlain by the basal Cambrian coarse and fine conglomerate and arkosic quartzites that comprise the Hellam conglomerate member of the Chickies quartzite. The axis of the Accomac anticline trends and pitches S.35°W., and the coarse conglomerate beds of the Hellam member make the crest of a ridge on the northwest limb of the anticline and Chimney rock on the southeast limb. These conglomerate beds also compose Mount Zion ridge, at the west end of the Mount Zion anticline, which trends S.70°W. Northwest of Pleasureville the Chickies quartzite is locally present on the north limb of the anticline.

The Mt. Zion and Accomac anticlines are broken by a fault on their northwest sides, and the Hellam conglomerate in these anticlines is thrust northwestward on the Glades overthrust, which diagonally transgresses the Dugan Run anticline and the Dee Run syncline, and, at the west end, the Emigsville syncline north of the fault. The Glades fault branches from the Chickies overthrust at the river, 1 mile west of Accomac.

The Chickies Rock anticline, near the river in eastern York County and east of the river in Lancaster County (see Pl. 26), is broken on its north side by the Chickies overthrust, and the Chickies quartzite is thrust northward over the limestone in the lowland to the north. At Accomac a branch of this fault, called the Highmount overthrust, passes into the Chickies Rock anticline, and has carried the Harpers phyllite, and, in places, the Antietam quartzite, on the south limb of the Chickies anticline over the Hellam conglomerate member and pre-Cambrian volcanic rocks in the Mt. Zion and Accomac anticlines. The fault is exposed in a ravine just south of Accomac, and at that point it dips 55°S.E. (See pl. 27 A.) The rock to the left of the hammer, which is at the thrust plane, is schistose metabasalt; the rock to the right is closely crumpled schistose mylonite of the thinner beds of the Chickies quartzite. The details of folding are not visible in the photograph of the outcrop, but are shown in microscopic form in plate 27 B, a photograph of a thin section of the mylonite rock. North of York the Antietam quartzite and older Cambrian rocks pitch west off the end of the Chickies anticline, and the Highmount overthrust here apparently trends northwest across the axis of the fold into the Kinzers formation on the north limb. (See fig. 9.) South of Emigsville, the beds of the Kinzers formation, overturned so that they dip 25° S., are thrust over Vintage dolomite on the north limb of the Emigsville syncline. The Chickies Rock anticline, therefore, appears here to be overthrust across the end of the Mt. Zion anticline, and the Glades overthrust to pass under the Highmount overthrust. A down-faulted



A. Highmount overthrust, exposed south of Accomac.



B. Photomicrograph of mylonitized Chickies quartzite, x6, at Highmount overthrust.

Light bands are quartz, between dark sericitic bands. Cleavage dips 55° SE.

block at the plunging end of the Chickies Rock anticline offsets the Antietam quartzite 1 mile eastward northeast of York, and complicates the structure.

Irregular masses of Kinzers formation apparently resting on Ledger dolomite make irregular shale and sandstone hills west and north of West York, and the inferred structure is shown on the geologic map. (Pl. 1.) Because the structures in the Kinzers formation in these blocks are truncated at their edges, the Kinzers does not dip under the surrounding Ledger dolomite in normal stratigraphic sequence, and the blocks are regarded as fault outliers, or klippen, of the Highmount overthrust block. (See fig. 11.)

EMIGSVILLE SYNCLINE

The Emigsville syncline is a symmetrical open syncline that lies between the Trout Run anticline and another anticline that brings up Chickies quartzite at the east edge of the Triassic basin, west of Starview. At the west the syncline is diagonally overlapped by the Triassic sedimentary rocks. It enclosed Vintage dolomite in the valley of Codorus Creek. South of Emigsville it is overridden by the Highmount overthrust block, and farther east, west of Glades, it is overridden by the Glades overthrust block.

PIGEON HILLS ANTICLINORIUM

The Pigeon Hills anticlinorium comprises the High Rock, Gnatstown, Menges Mill, Mt. Carmel, and Ambau anticlines. (See fig. 10.) The High Rock, or the major, anticline, exposes a large area of pre-Cambrian metabasalt at the core, and pitches northeast, and the Antietam quartzite in the anticline makes a symmetrical arc where it passes beneath the limestone, east of Roth Church. The fold is broken along its entire length by a longitudinal normal fault, and is cut at its west and east ends by several cross faults. The northwest limb is concealed by Triassic redbeds, which lap up on the metabasalt in the center of the fold. The southeast limb is cut off by the Gnatstown overthrust, which separates it from the Gnatstown anticline to the south.

The Gnatstown anticline is best shown northeast of Gnatstown, where the Hellam conglomerate member of the Chickies quartzite is exposed at the core. Southwestward pre-Cambrian metabasalt is exposed at two places in the core of the fold. The fold pitches northeastward, and the Antietam quartzite in the anticline extends beyond that of the High Rock anticline, to a point 1½ miles northeast of Nashville, where it is cut out by the Gnatstown overthrust, which there passes into higher beds in the anticline. The Menges Mill anticline is a nearly symmetrical smaller fold exposing Harpers phyllite in the core, and also pitches northeast. The Ambau anticline is a still smaller fold to the south, which brings up Antietam and Harpers in the limestone lowland. It also pitches northeast. The Mt. Carmel School anticline is a double fold which may represent the Menges Mill and Ambau anticlines west of a cross fault. The Pigeon Hills anticlinorium ends

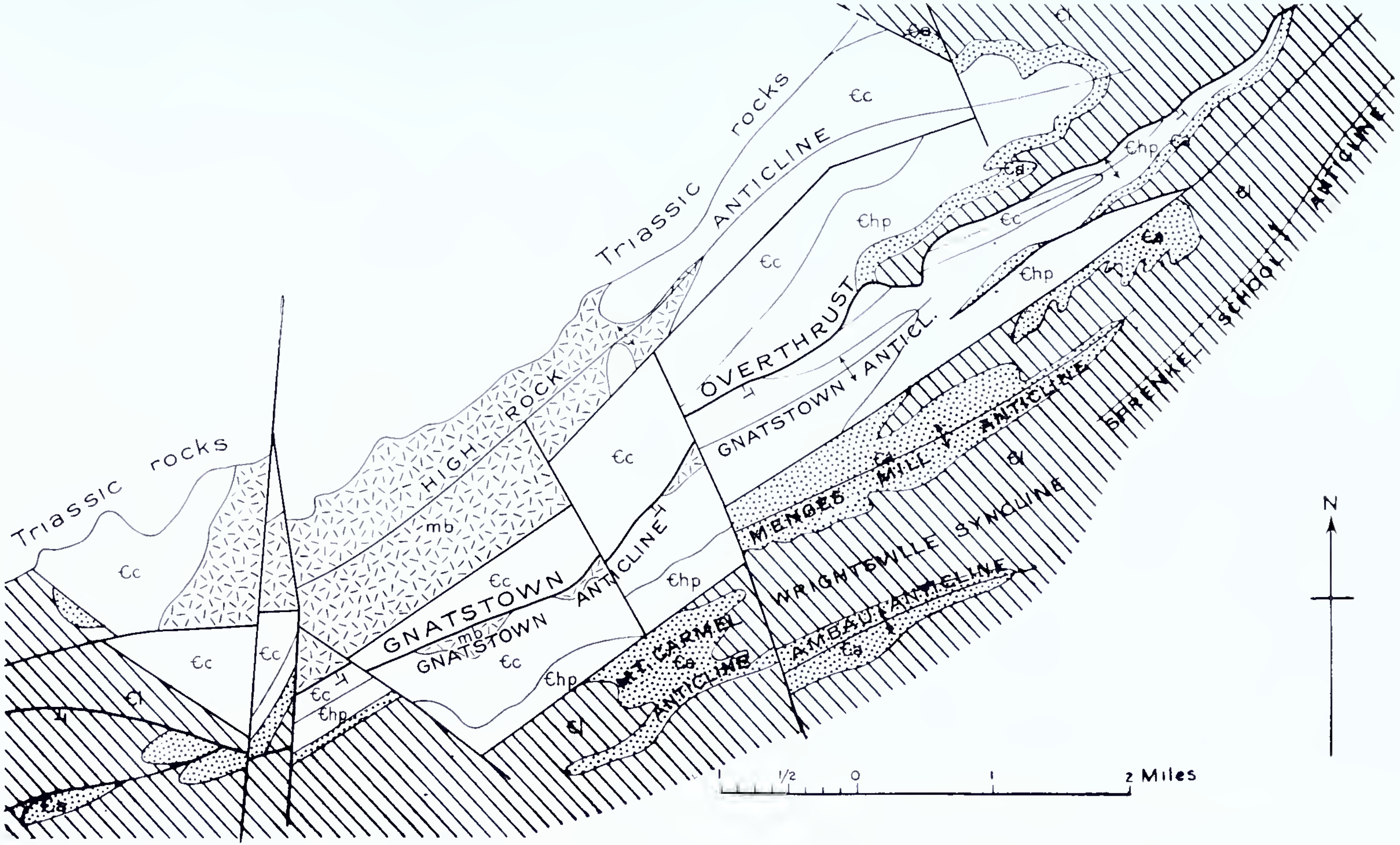


Figure 10. Sketch geologic map showing structural axes in the Pigeon Hills. Єl, Cambrian limestones; Єa, Antietam quarzite; Єhp, Harpers phyllite; Єc, Chickies quartzite; mb, pre-Cambrian metabasalt.

abruptly in eastern Adams County, in part because of its steep southwest pitch, and in part because of down faulting.

The Gnatstown overthrust extends eastward from the Pigeon Hills uplift, and, northeast of Nashville, passes north of the small Pottery Hill anticline, where the fault is exposed in an old quarry on the south side of the Lincoln Highway, U. S. 30. Here the Harpers phyllite is overthrust on the Ledger dolomite. (See Pl. 28 A.) Northeastward, in the city of York, the overthrust is not clearly traceable, but this fault is believed to be continuous with the Highmount overthrust of the Hellam Hills uplift, and the klippen of Kinzers formation, surrounded by Ledger dolomite as described under the Hellam Hills anticlinorium, are believed to be outlying remnants of the Gnatstown-Highmount overthrust block. (See fig. 11.)

SPRENKEL SCHOOL ANTICLINE

The Sprenkel School anticline comprises an anticlinal belt of hills composed largely of Kinzers formation that extends from Spring Grove northeastward for 6 miles. Along the axis of the fold Vintage dolomite is exposed at two places, one northeast of Spring Grove and the other northeast of Sprenkel School. The latter area is 2 miles long. At the north end of these shale hills a small anticline exposes Antietam quartzite and Harpers phyllite in Pottery Hill, southwest of West York, previously mentioned.

WRIGHTSVILLE SYNCLINE

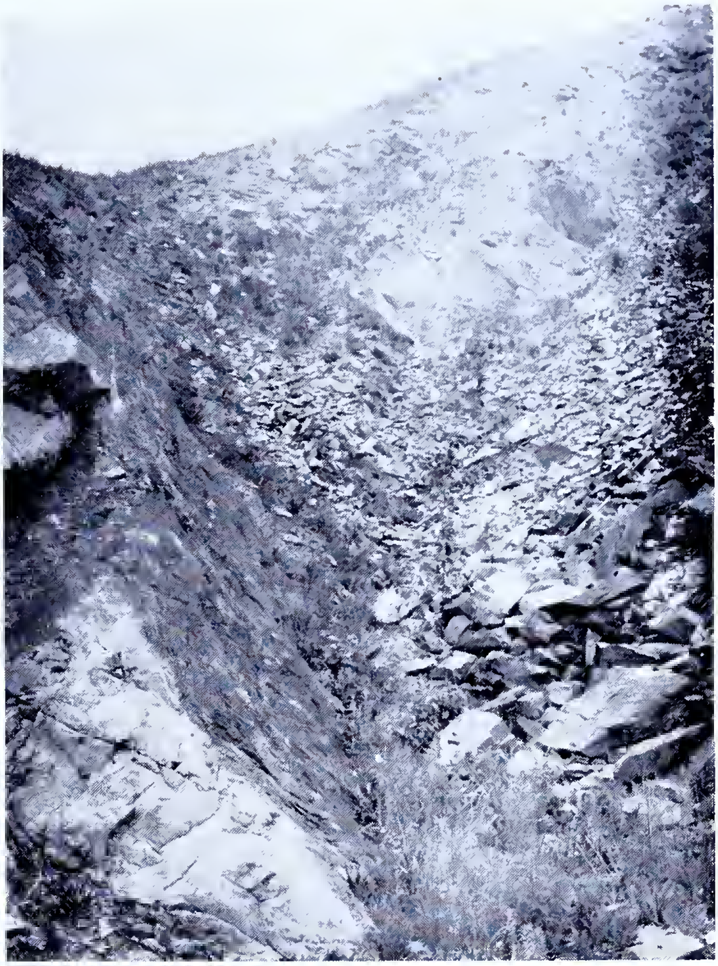
The Wrightsville syncline encloses limestones which form the Hanover-York valley. The synclinal character of the valley is best shown from York to the Susquehanna River, where it contains chiefly Conestoga limestone, with older limestones on its north and south borders. It here lies between the Hellam Hills anticlinorium and the Stoner overthrust. A minor fault in the limestone is exposed in the quarry of the York Valley Lime & Stone Co. (Pl. 28 B.) Near the river the Strickler anticline rises south of the syncline. South of York the syncline is not so deep, and anticlines of older limestones are exposed in the Conestoga limestone area of the valley southwest of York. The syncline here lies between the Sprenkel School anticline and the Stoner overthrust, and is greatly constricted and practically terminated north of Iron Ridge by the Ambau anticline. The Hanover valley is another broad syncline along the same axis, in which Conestoga limestone is enclosed.

STRICKLER ANTICLINE

The Strickler anticline lies south of the Wrightsville syncline for a mile west of the river. Westward it is transgressed and largely concealed by the Stoner overthrust, and only the Lower Cambrian formations on the north limb of the anticline are exposed along the south side of the valley as far west as Plank Road.

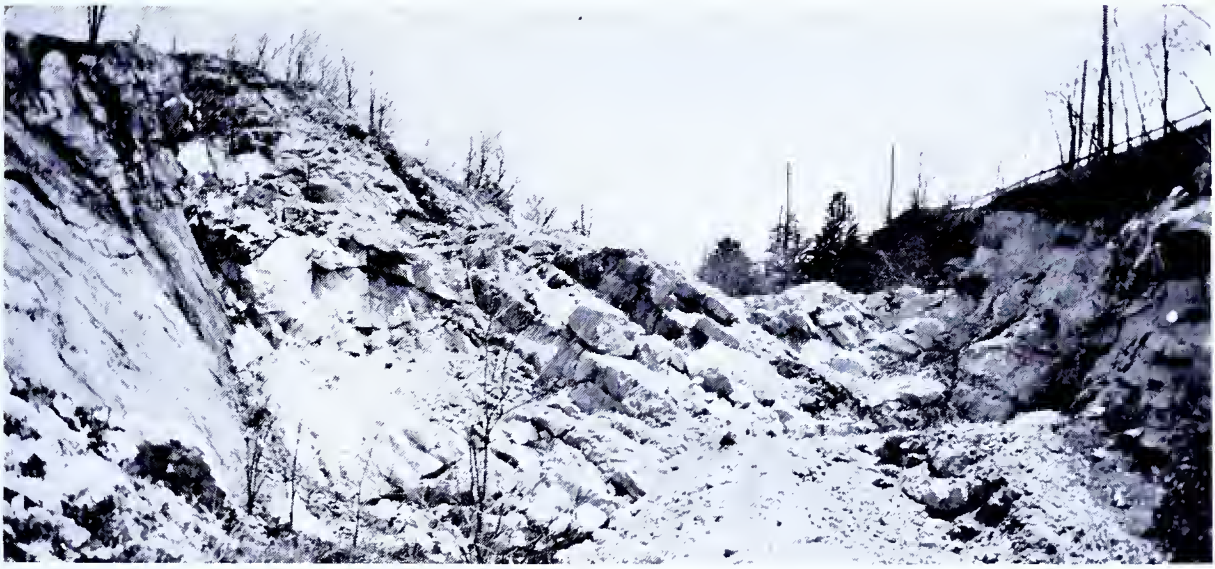
STONER OVERTHRUST

The Stoner overthrust crosses the county in a southwest direction from the river to the western edge of the county. The Lower Cambrian quartzose rocks in the Stoner overthrust block are thrust north-



A. Gnatstown overthrust exposed in quarry at Pottery Hill on Highway U. S. 30.

Harpers phyllite, at right, thrust over Ledger dolomite, at left. Fault plane dips 55° to the right.



B. White marble in middle part of Kinzers formation thrust over argillaceous limestones of same formation.

East end of quarry of York Valley Lime & Stone Co. Fault plane at left, dips 60° S. Fossils collected from argillaceous limestone at top of quarry, at left.

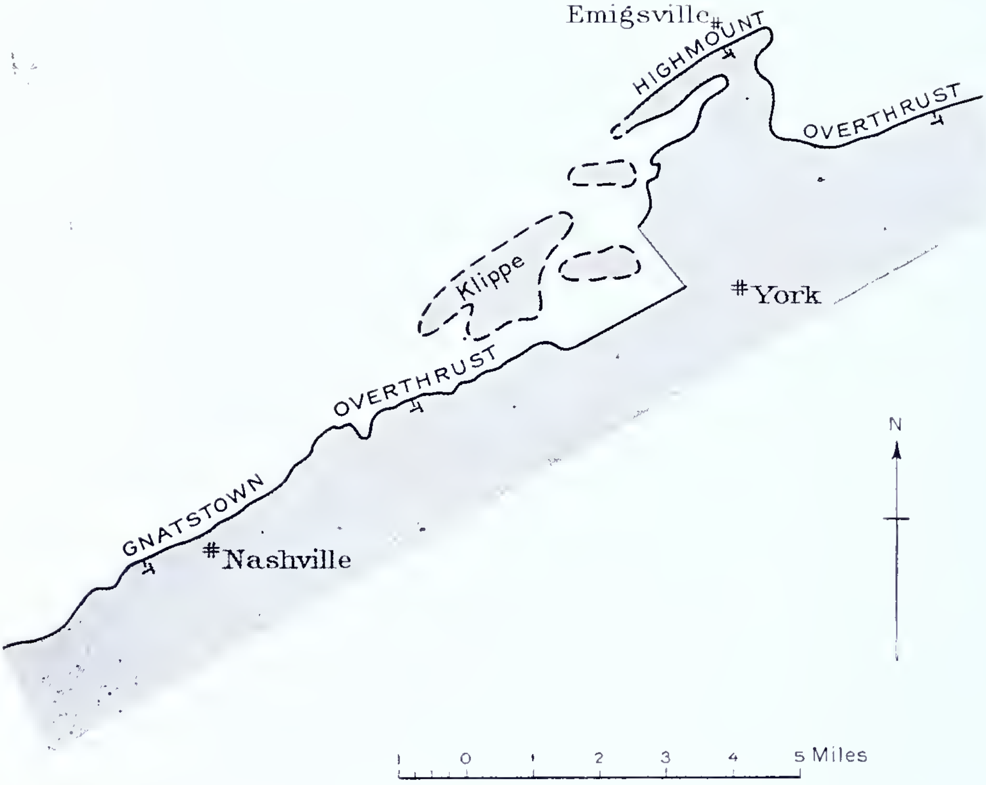


Figure 11. Sketch map showing relation of the Gnatstown and the Highmount overthrusts.

Shaded area, Gnatstown-Highmount overthrust block.

westward over the limestones of the Wrightsville syncline. East of Plank Road these rocks override the north limb of the Strickler anticline, which emerges from beneath the overthrust where the thrust swings more southeasterly near the river. South of York the Stoner overthrust block rides over minor anticlines, already described, in the Wrightsville syncline. West of York New Salem the Harpers phyllite of the overthrust block caps a low hill in the valley of Codorus Creek, which is composed of Kinzers formation in an anticline, and to the west an eroded remnant of the Harpers in the thrust block overlies Conestoga limestone in the valley. At Ambau the Harpers phyllite in the Stoner block overrides the south limb of the Ambau anticline. West and south of Iron Ridge the Stoner overthrust plate is greatly dissected, and deep reentrants of the overridden limestone lie between long remnants of the overthrust block that project southwestward into the limestone lowland, and several small remnants of the thrust block composed of the Harpers lie out in the lowland southwest of Iron Ridge. (See fig. 12 and Pl. 29 A.) Penn Grove valley, which is the largest of these reentrant limestone valleys, is so nearly cut off at its west end that it is almost a window in the overthrust plate. South of Hanover the Harpers of the Stoner block is thrust over Antietam quartzite in a small anticline in the Hanover valley.

STONER OVERTHRUST BLOCK

The Stoner overthrust block, bounded on the north by the Stoner overthrust, is overridden on its southeast margin by the Martic overthrust, and varies in exposed width from 2 to 4 miles. (See fig. 12.) It comprises the Mt. Pisgah, Holtz, Berkheimer School, and Kraft Mill anticlines, and the East Prospect, Stormy Hill School, and Jefferson synclines. All of these folds are overturned to the northwest so that their axial planes dip southeastward. The Mt. Pisgah anticline, which extends from the river nearly to York New Salem, exposes the Chickies slate, which has several quartzite beds in it, and the Hellam conglomerate member of the Chickies is exposed at the highest part of uplift, from Mt. Pisgah Church to Yorkana. The Chickies slate, with quartzite beds, is also exposed in the Holtz, Kraft Mill, and Berkheimer School anticlines. The Holtz anticline is long and narrow, having a length of about 9 miles, and is thrust northward on the Ore Valley overthrust. The Kraft Mill anticline is nearly 12 miles long and about 1 mile wide.

The Stormy Hill School syncline is a narrow fold that encloses Antietam quartzite and Vintage dolomite, and is 3½ miles long. The Jefferson syncline is a much larger syncline enclosing Antietam quartzite and Conestoga limestone, with Vintage dolomite showing in one or two places. It is a double syncline, with a midrib of Antietam quartzite between 2 valleys of limestone, and is ¾ mile wide in its broadest part. Another syncline to the southwestward, along West Branch of Codorus Creek, is on the same strike and encloses the same formations. The total length of the Jefferson syncline and its southward extension is nearly 14 miles. It forms the southeast margin of this part of the Stoner block, and is overridden by the rocks of the Martic overthrust block.

The East Prospect syncline lies south of the Mt. Pisgah anticline, and contains Antietam quartzite and overlying limestones. It has a length of 13 miles, extending westward from the river to north of Spry. The syncline is deepest in its eastern part, where it has a maximum width of 2½ miles. In this wider part, the limestone is enclosed in 3 synclinal folds that pitch east, and limestone is exposed, or believed to be present, also at 3 places in infolds within the Antietam quartzite area to the southwest. The syncline is cut off on its southeast side by the Ore Valley overthrust along the north side of the Holtz anticline, and, farther east, by the Martic overthrust, where the rocks of the Martic block override the Conestoga limestone in the East Prospect syncline.

South of Margaretta Furnace there is another small syncline that encloses Antietam quartzite and Conestoga limestone. It lies between the Ore Valley overthrust and the Martic overthrust.

Structure of Martic overthrust block

GENERAL DESCRIPTION

The Martic overthrust block occupies the southeastern part of York County and comprises chiefly rocks of the Glenarm series and the Cardiff conglomerate and Peach Bottom slate. Its northern edge ex-

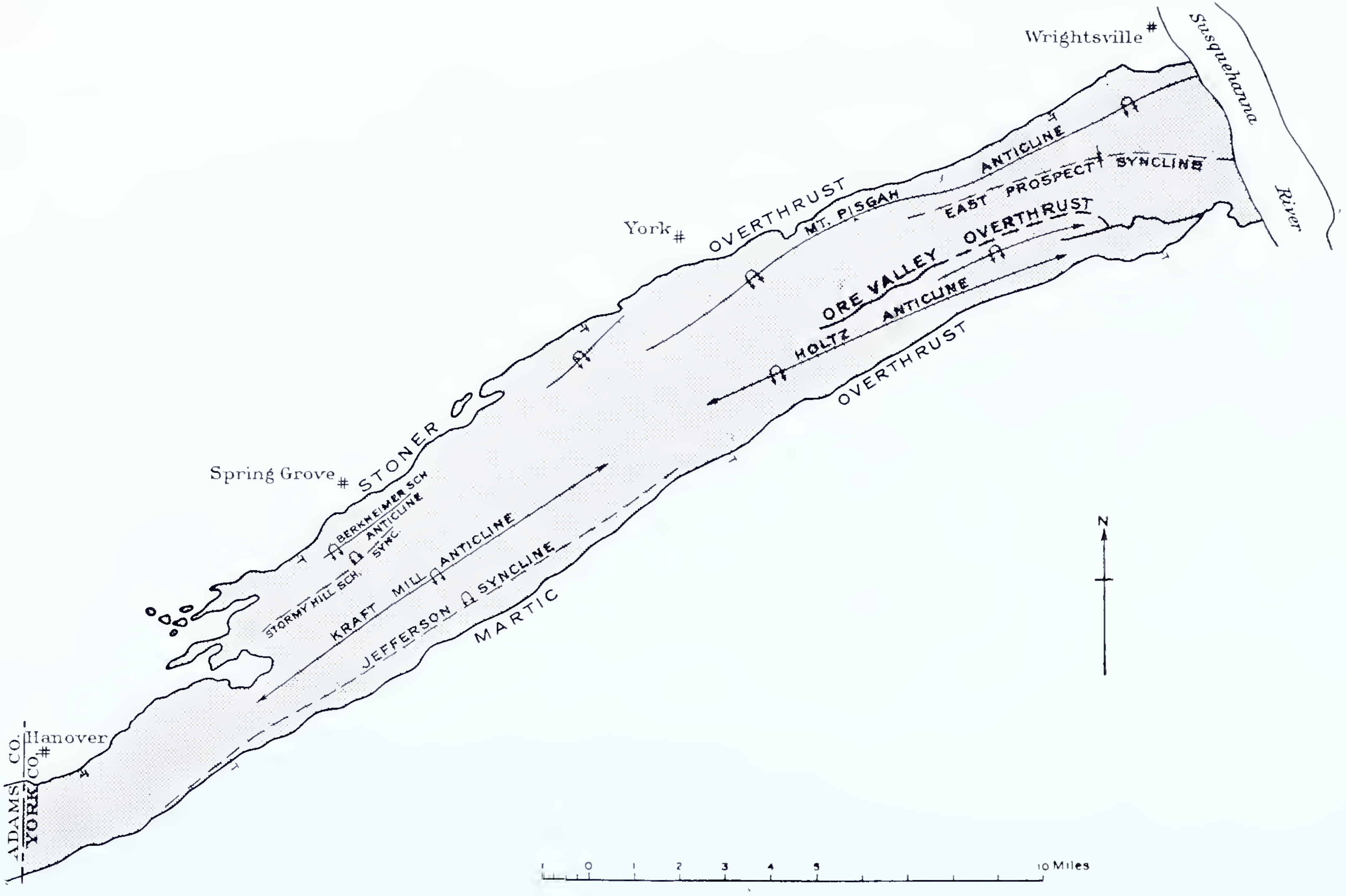
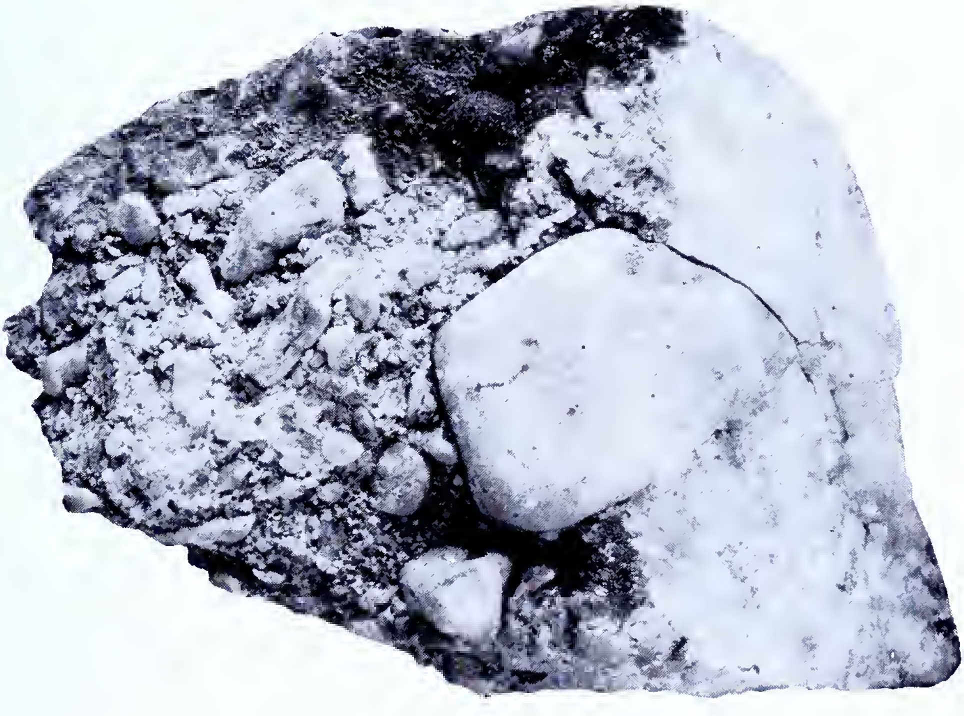


Figure 12. Sketch map of Stoner overthrust and Stoner block in York County.
Shaded area, Stoner overthrust block.

A. Hill of Harpers phyllite in limestone lowland, remnant of the Stoner overthrust block. 1 mile southwest of Jacobs Mill.



B. Slickensided quartz pebble in Triassic conglomerate on normal fault plane. ¼ mile north of La Bott.

tends from Long Level at Susquehanna River southwest through Relay, Jacobus, Seven Valleys, Jefferson, Sinsheim, and Fairview School, two miles southwest of which place it passes out of the county. The Marburg schist occupies the northwestern part of this thrust block and is in contact with Conestoga limestone, Antietam quartzite, and Harpers phyllite north of the overthrust. Where the Marburg schist is in contact with Harpers phyllite the overthrust is indicated on the map by a dashed fault line because these two formations resemble each other somewhat, and it is difficult to locate the fault boundary exactly. The main folds of the Martic overthrust block in York County from northwest to southeast are the Yoe and Wentz synclines, Tucquan anticline, and Peach Bottom syncline. (See fig. 13.)

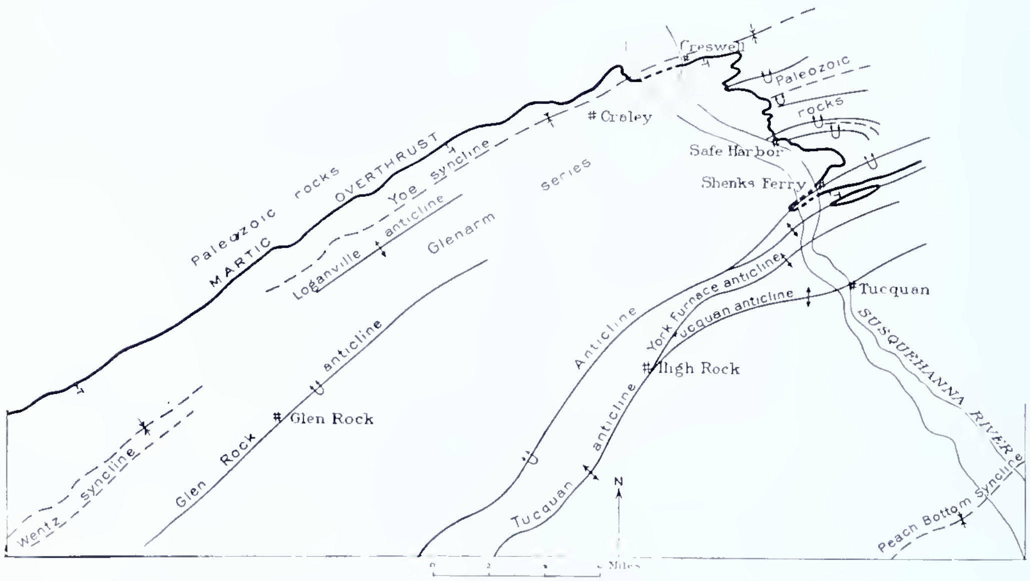


Figure 13. Sketch map showing major structural axes of the Martic overthrust block in York County and adjacent part of Lancaster County.

Tucquan anticline.—The Tucquan anticline crosses the southeastern part of York County and extends from York Furnace on Susquehanna River to the Maryland line near Deer Creek. It was first described in the report on the McCalls Ferry-Quarryville district[12] where the Mine Ridge anticline is developed in pre-Cambrian and overlying lower Paleozoic rocks of the overriden block. The Paleozoic rocks plunge southwestward off the nose of the Mine Ridge anticline, and the youngest of the Paleozoic formations, the Conestoga limestone, passes southwestward under the albite-chlorite schist of the Wissahickon formation. Mine Ridge is a double arch and the Tucquan anticline which is its southwestward continuation is developed in the Wissahickon formation as a double arch southwestward across Lancaster and York Counties to a point near High Rock. Southwestward it is a single anticline which follows South Branch of Muddy Creek and extends southwestward to the Maryland line near Deer Creek.

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[12] Knopf, E. B., and Jonas, A. I., op. cit., Bull. 799, p. 73, 1929.

At the crest of the Tucquan anticline in York County the foliation and the axial planes of the recumbent folds are horizontal or gently rolling. The dip of the foliation and of the axial planes of the folds gradually steepen away from the crest of the anticline in the direction of the Peach Bottom syncline to the southeast and of the border of the Wissahickon formation to the northwest.

The foliation throughout this area is cut by a steep transverse cleavage. (See Pl. 30 A.) The foliation is closely folded and the steeply dipping cleavage, which is more prominent in the micaceous layers, is parallel to the axial planes of the minute folds of this folding. The steeply dipping cleavage has a smooth surface in contrast to the somewhat curved or irregular surface of the foliation layers. Just south of the northwestern boundary of the Wissahickon formation the foliation dips 50° to 55° NW. and the transverse cleavage dips 70° NW., into the Wentz syncline which lies northwest of the Wissahickon formation and contains the Marburg schist and infolds of quartzite associated with the schist.

Yoe syncline.—The Yoe syncline encloses black slate and quartzites associated with the Marburg schist, which are believed to be the youngest beds present in this part of the area. In eastern York County the transverse cleavage dips about 80° NW. from the Tucquan anticline to the axis of the Yoe syncline, which passes just north of Craley. North of the axis to the edge of the Martic overthrust and in the Paleozoic rocks to the northwest the transverse cleavage dips 80° SE. into the syncline. The exposures of the rocks in the Yoe syncline are very poor because they occupy an upland area. The eastward extension of the syncline passes out of the Marburg schist into the underlying Conestoga limestone north of Long Level. In Lancaster County, north of Cresswell, the bedding and cleavage in the Conestoga limestone dip southeast into the syncline.

Wentz syncline.—This syncline lies southeast of the strike of the Yoe syncline, and, southwest of Highway U. S. 111, also contains infolds of quartzite associated with the Marburg schist. These quartzites become more numerous near the Maryland line, where the syncline is deeper. The syncline is named from Wentz, Maryland, 1½ miles south of West Manheim. The main part of the syncline passes through Huntrick Hill, Brodbeck, and Beecher Hill, and infolds of quartzite occur as far northwest as Zumbrum School. To the northeast of the valley of Codorus Creek, where it flows through Brodbeck, the transverse cleavage dips northwest in the syncline, and this dip continues northwestward to the edge of the Martic overthrust. The northwest-dipping cleavage probably reflects overturning of the folds to the southeast, although the exposures are not good enough to establish this suggestion. At Brodbeck and southwest of Codorus Creek the cleavage is vertical to 80° NW. In a parallel valley to the west, which passes through Marburg, the cleavage dips southeast, and this direction of dip continues northwestward for 5 miles to the northwestern part of the Martic overthrust block. The small folds, where visible, show pitching axes, but no beds can be continuously traced in the Marburg schist. The quartzites to the south form more continuous ledges, and show a curving strike, and, where folds are exposed, they have inclined axes.

Loganville anticline.—The Loganville anticline which lies between the Yoe and Wentz synclines, exposes blue crystalline limestone in a narrow valley northeast of Loganville. This crystalline limestone is similar to the blue, slaty-banded Silver Run limestone, where it is widely exposed on the northern side of the main marble-volcanic belt in Maryland. The fold axes in the Marburg schist on the north side of the valley near Loganville are horizontal, and the axial planes are overturned to the southeast. Folds in a tongue of schist that divides the western part of the limestone, and forms a hill south of an abandoned limonite pit, pitch 45° SW. Grayish-white marble, seen only in an abandoned quarry to the east of the road along Codorus Creek, southeast of Zumbrum School, is along the same general strike, 12 miles southwest of the Loganville area.

Glen Rock anticline.—Elongate areas of metabasalt, infolded in the Wissahickon formation, lie northwest of the Tucquan anticline and southeast of the Wentz syncline. The axial planes of the folds in these rocks dip northwest, and the amount of dip increases from 35° near Anstine to 70° north of Glen Rock. These areas of metabasalt and associated Wakefield marble near the Maryland line are regarded as anticlinal, because in Maryland, where they are more widely exposed, they appear to lie, in large part, beneath the albite-chlorite schist facies of the Wissahickon formation. If this be the case, however, it may seem strange that the marble and volcanic rocks are not exposed in the Tucquan anticline, the major uplift of the Wissahickon formation. If, as the presence of recumbent folds indicates, the rocks were originally folded into large recumbent folds, during or before overthrusting, and the present superposition of layers does not represent a true stratigraphic succession, the marble-volcanic rocks now exposed in the Glen Rock anticline may represent an arching up of an earlier large recumbent anticlinal uplift.

The Peach Bottom syncline.—This syncline crosses southeastern York County about 10 miles southeast of the Tucquan anticline. It contains the Peters Creek quartzite, the Cardiff conglomerate and Peach Bottom slate. The Cardiff and Peach Bottom are infolded in the Peters Creek from Kings Bridge, Lancaster County, to Pylesville, Md., 3½ miles southwest of Cardiff and Delta at the Pennsylvania line.

In York County the transverse cleavage in the Peters Creek quartzite and the cleavage in the Cardiff conglomerate dip steeply into the syncline. In the Peach Bottom slate the cleavage is uniformly nearly vertical, varying usually only 10° from the vertical. Curved partings seen in many of the slate quarries and called "slaunts" by the quarrymen are believed to be bedding. On the surfaces of these layers there is a fluting formed by the intersection of the cleavage and the layering. The direction of the lineation on the fluted layers and on cleavage planes shows the strike of fold axes, and the inclination of the lineation shows the pitch of the fold axes. In the Funkhauser quarry, 1 mile northeast of Delta, the fold axes are horizontal. Farther northeast the axes dip southwest into the syncline. At the southwest end of the Cardiff conglomerate and the slate, in Maryland, the lineation and fold axes pitch northeast into the syncline.

The Cardiff conglomerate and the enclosed slate lie in three minor synclines separated by two minor anticlines, and these folds make up the center of the Peach Bottom syncline. (See fig. 5.) These folds conform to the minor folding seen in the Cardiff conglomerate at Pylesville, Md., where it follows around the southwest end of the syncline in a canoe-shaped end, made up of three synclines and two anticlines that pitch gently northeastward. The northern and central synclines extend to a point less than ¾ mile west of Slate Hill and the southern extends to the river and northeastward into Lancaster County. The lower layers of the slate contain quartz veins and are closely folded, and do not produce good cleavable roofing slate.

RELATION OF THE FOLDS IN THE GLENARM SERIES AND IN THE PALEOZOIC ROCKS

In the Mine Ridge anticline the true order of the stratigraphic sequence of the Paleozoic rocks overlying the pre-Cambrian core of the fold can be determined by measuring from below upward in the direction of the pitch, that is, to the southwestward. The schists that overlie the Conestoga limestones and are folded into the Tucquan anticline also pitch southwestward, but the above rule for determining sequence cannot be applied to the schists because of the isoclinal and recumbent folding and shearing out of the folds, which has taken place in them. It is evident that in this arch the Wissahickon formation and the underlying Paleozoic rocks are folded together. At Shenks Ferry Station, Lancaster County, the Paleozoic limestone and Antietam quartzite are exposed in an anticline north of the main area of the Martic overthrust block, but north of Shenks Ferry Station the schists of the Glenarm series are again exposed on the east side of the river and extend in a narrow band for 7 miles northwestward to

East of these schists Paleozoic rocks are exposed, and include in ascending order, the Antietam quartzite, Vintage dolomite and Conestoga limestone, which occur in closely appressed anticlinal and synclinal minor folds on the northwest flank of Mine Ridge anticline. East of Safe Harbor these rocks have curving strike and the sequence is repeated many times in the pitching folds. The axial planes of the folds are overturned to the southeast and the beds dip north from Shenks Ferry Station northwest to the eastern extension of the Yoe syncline that lies north of Cresswell.

At the western nose of the minor anticlines that lie north and south of Safe Harbor, the Antietam quartzite pitches 20° W. under the overlying Vintage dolomite, and the Vintage, in turn, pitches westward under the Conestoga limestone. This limestone, and the Vintage dolomite in places, pitch under the Wissahickon formation that borders the river northwest of Shenks Ferry Station and erosion has removed the schists a short distance east of the river, and exposed to view these underlying Paleozoic rocks along the rise of the pitching folds. It is evident, therefore, that the schists of the Martic overthrust block were folded together with the Paleozoic rocks in the Mine Ridge anticline and on its northwestern flank.

EVIDENCE OF OVERTHRUSTING

The question will be asked, therefore, if the fold axes in the two groups of rocks are conformable, on what structural evidence does the overthrust character of the schists rest? In the Tucquan arch in York County, as has been stated, the schists of the Wissahickon formation contain two schistose structures, a flat-lying foliation which was later squeezed into folds which are cut by a tranverse cleavage. In discussing the Wissahickon albite-chlorite schist, evidence has been given to show that this foliation (see Pl. 30, A & C.) is an earlier ''transposition'' cleavage produced by slipping in closely appressed recumbent folds which have been more or less completely destroyed. Recumbent folds, both megoscopic (see Pl. 30, B.) and microscopic, occur in the Wissahickon schist. Foliation structure in which recumbent folds have been partly or entirely destroyed so that the schist is made up of a thinly laminated alternation of micaceous and quartzose layers is common in that formation. The quartzose layers are in large part discontinuous and form lenticles completely surrounded by the micaceous envelope and lie parallel to the layering of the schist. (See Pl. 30, A & C.) If the original layering of the argillaceous and quartzose series which was folded into recumbent folds was bedding, the foliation is also largely parallel to the bedding, but, because the original position of the layering has undergone a complete transposition, the present superposition of the foliation layers is not a stratigraphic succession. It is these foliation layers that have been folded into the Tucquan anticline and crumpled into the minor folds on its flanks, coincident with the upfolding of Mine Ridge anticline.

Recumbent folds[13] are found also in Maryland in the rocks of the Glenarm series, namely in the Setters formation, the Cockeysville marble, and the oligoclase-mica schist and albite-chlorite schist facies of the Wissahickon formation. They occur also in the Baltimore gneiss in Maryland which underlies the Glenarm series. These recumbent folds are on a small scale, and the magnitude of the recumbent folding cannot be determined in the field owing to lack of sufficient vertical extent of outcrop. It seems possible that the recumbent folds on a small scale may reflect a large scale structure developed during the forward movement of the Glenarm series by which it has come to lie on the known Paleozoic rocks, and that the displacement has taken place by a large scale recumbent fold. A similar type of folding has been described in the Taconic area.[14] Recumbent folding was suggested[15] also for the major structure of the Woodville anticline, Chester County, Pa.

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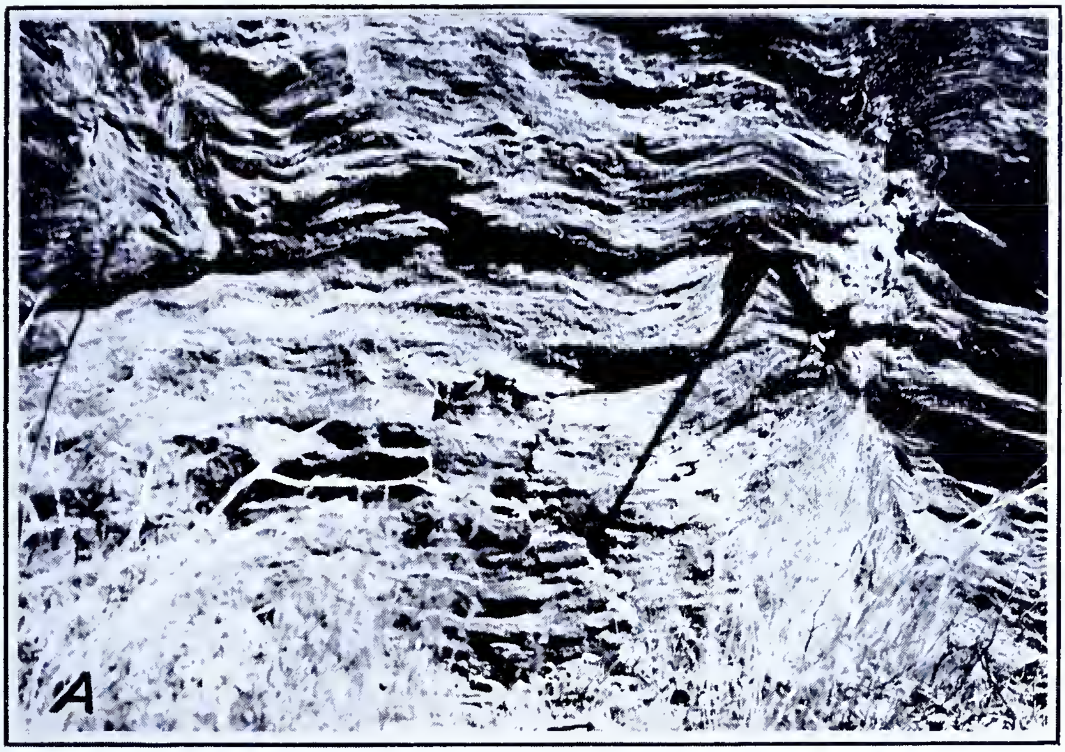
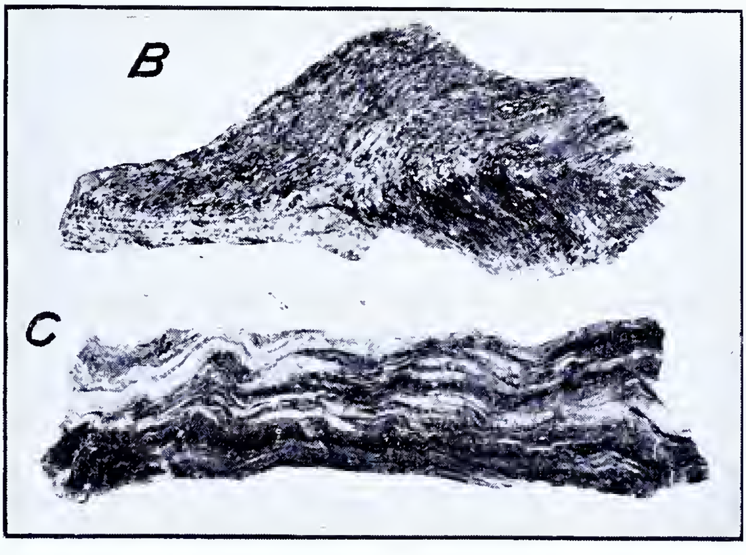
[13] Jonas, A. I., Tectonic studies in the crystalline schists of southeastern Pennsylvania and Maryland: Am. Jour. Sci., vol. 34, pp. 367-368, 1937.

[14] Prindle, L. M., and Knopf, E. B., Geology of the Taconic quadrangle: Amer. Jour. Sci., vol. 24, pp. 293-298, 1932.

[15] Bailey, E. B., and Mackin, J. H., Recumbent folding in the Pennsylvania Piedmont, Preliminary statement: Am. Jour. Sci., vol. 33, pp. 186-190, 1937.



A. Foliation, with folds sheared out, in Wissahickon schist, lying nearly horizontal, showing later minor folding and steep transverse cleavage.
At Otter Creek, ½ mile south of Shenks Ferry.



B. Recumbent fold with axial plane lying horizontal, in Wissahickon schist, from Tucquan anticline at High Rock.
Polished specimen, natural size.

C. Foliation in Wissahickon schist, lying horizontal, showing minor folding and steep transverse cleavage, from Tucquan anticline at Susquehanna River.
Polished specimen, natural size.

The fact that the schists of the Martic overthrust block do not appear on the north side of the Mine Ridge anticline and that the early recumbent folding which has been deformed by the latest folding has not been observed in the Paleozoic rocks, strongly indicates that the recumbent folding in the Glenarm series sequence is a manifestation of a movement confined to these schists, by which they were extensively displaced and brought to lie in structural discordance over the Paleozoic carbonate rocks. From the evidence available, it is not possible to state, however, whether the recumbent folding occurred in a different orogenic period from the folding that involved the Paleozoic rocks, or whether it is merely an earlier phase of the same orogeny as the latter folding.

AGE OF THE STRUCTURES

Because the rocks of the Martic overthrust block rest on Conestoga limestone of probable Ordovician age, the date of the overthrust is post-Conestoga. Since the Conestoga limestone in Chester Valley contains Beekmantown fossils,[16] the thrust fault is known to be of post-Beekmantown age. The folding of the Paleozoic carbonate rocks and of the overlying schists, which produced the major anticlines and synclines of the area, is parallel to the axes of broad folding of the Appalachian Valley to the northwest, and therefore is probably of the same age, late Paleozoic. This folding was later than the recumbent folding and formation of foliation layers that were developed during or before the forward movement of the Martic overthrust block. No evidence has been found to show whether the overthrusting of the Martic block and later folding were two stages of late Paleozoic orogeny or whether overthrusting and recumbent folding took place earlier than the late Paleozoic.

TRIASSIC STRUCTURES

Structures in the Triassic Rocks

The Triassic rocks, which cover a wide area in the northern part of the county, were not folded, as were the older rocks, but were tilted northwestward at an angle of about 30°. At their northwestern margin these rocks were down-faulted, with a large displacement which has been estimated to be many thousand feet. This down-faulting tilted the beds northwestward and occurred in large part during the sinking of the basin and deposition of the sediments, and continued to the close of the Triassic period. Normal faults also cut across the strike of the beds and offset them. Near the close of Triassic time molten basaltic lava entered these rocks along the fault zone at the northwestern border of the area and pushed in between the layers of sediments as sills and cut cross them as dikes.

The line of faults along the northwestern border has a general N.50°E. trend, and, to the northeast, near the river, it bends more nearly east. The border fault is broken and offset by many northwest trending faults. Northeast of Bowmandale some of the northwest-trending faults that offset the boundary fault are followed by small diabase dikes. South of Stone Head, near the Adams County line, the border fault brings pre-Cambrian aporhyolite against Triassic sedimentary rocks and diabase. Just north of Dillsburg a rectangular fault block lies northwest of the boundary fault, and contains a thin layer of Gettysburg shale with interbedded limestone conglomerate that dips northwest and rests normally on Elbrook limestone. These Triassic beds lie northwest of the Triassic basin, and apparently these youngest Triassic beds overlapped the edge of the down-faulted basin onto the limestone northwest of the border fault. Similar relations were observed north of York Springs, Adams Co., 2½ miles southwest of the York County line, where Paleozoic limestone is exposed beneath flat-lying Triassic rocks along a small valley for 3 miles from the west edge of the Triassic.

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[16] Stose, G. W., and Jonas, A. I., Age reclassification of the Frederick Valley (Maryland) limestone: Geol. Soc. Amer. Bull. vol. 47, pp. 1671-1673, 1936.

The southeast border of the Triassic rocks is similarly offset by transverse faults south of Abbottstown, in Adams County, and in the vicinity of La Bott. The displaced conglomerate beds at these faults show slickensiding on fractures that cut through quartz pebbles. (See Pl. 29 B.) North of Emigsville three minor faults, with N.65°E. trend, offset the boundary. At Yorkhaven and northwestward to Newberrytown the large diabase dike is cut and displaced by four faults with similar northeast trend. Probably there are many more such faults within the Triassic rocks which cannot be recognized because of the uniform appearance of the beds.

Triassic normal faults in the Paleozoic rocks

Normal faults that occur only in the Highmount overthrust plate, north of York, apparently are older than Triassic, and are the result of the fractionation of the plate during late Paleozoic overthrusting. Many other normal faults that cut the Paleozoic rocks, however, are assigned to the Triassic period.

Several transverse faults cut the Paleozoic rocks in a N.30°W. direction, and offset the structures in those rocks. They apparently terminate in other normal faults that trend N.50° to 60°E. and tend to produce a rhombic fault pattern. (See fig. 14.)

A cross fault that strikes about N.30°W. cuts the end of the Mt. Zion anticline and crosses the limestone lowland east of York, following Mill Creek to Plank Road, and is called the Plank Road fault. It offsets the Stoner overthrust ¼ mile, the west side having moved relatively northward. The Antietam quartzite and higher formations on the south limb of the Wrightsville syncline, just north of the Stoner overthrust, are similarly offset. In the gorge of Mill Creek, to the south, the quartzite beds in the Chickies slate and the infolded Harpers phyllite are similarly broken across and offset in the same direction. On the north limb of the Wrightsville syncline the Kinzers formation and Vintage dolomite east of the cross fault are terminated abruptly by the fault, but there are no exposures in the Mill Creek lowland west of the fault.

A nearly parallel cross fault follows the local course of East Branch of Codorus Creek, southeast of West York, and passes near the York Country Club, and is therefore called the Country Club fault. It offsets the Stoner overthrust northward on the east side. South of this overthrust, Harpers phyllite west of the cross fault is in contact with Chickies slate to the east. In the limestone valley north of the Stoner overthrust, an anticline that brings up Kinzers formation and Vintage dolomite is cut in two, but the two parts of the fold do not match. The Country Club fault terminates at the north in a strike fault, which is apparently a normal fault with downthrow to the south. The Country Club and the Plank Road cross faults appear to end at the south in another strike fault which also has downthrow to the south.

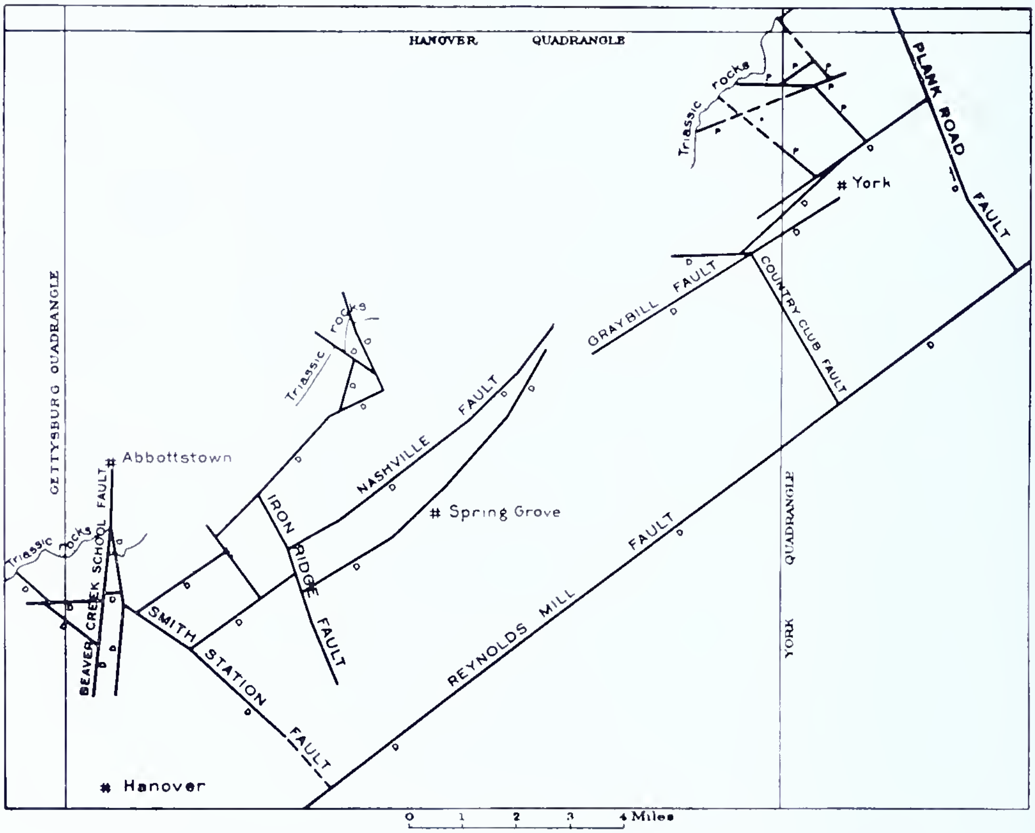


Figure 14. Sketch map of normal faults in York County.

Faults marked P apparently affect only the Highmount overthrust block, and are of Paleozoic age.

The Pigeon Hills anticlinorium is cut by several transverse faults which intersect the structures nearly at right angles. Near the west end of the anticlinorium two nearly parallel faults, called the Beaver Creek School faults, converge and join northward. These faults not only offset the structures in the older rocks, but extend into, and offset, the Triassic rocks to the north, and are, therefore, in part, at least, of Triassic age. Two other cross faults, which terminate the north arm of the High Rock anticline, also cut and offset the Triassic rocks between Farmers and La Bott, and are, in part, of Triassic age.

The Iron Ridge cross fault, which trends about N.30°W., breaks across the Pigeon Hills anticlinorium near Gnatstown and offsets the structures. At Iron Ridge it offsets the Stoner overthrust northward on the west side. The cross fault terminates at the north in a northeast-trending normal fault within the High Rock anticline. A shorter parallel cross fault, 1 mile to the west, also cuts the Pigeon Hills structures, and apparently breaks the northeast-trending normal fault, above referred to. At the south it terminates in another northeast-trending normal fault. A cross fault that trends more northwesterly cuts off the southwest end of the Gnatstown anticline and terminates at the north in the Beaver Creek School fault. Southeastward it crosses the limestone lowland, and offsets the Stoner overthrust at Smiths Station, and is therefore called the Smiths Station fault. The thin plate of the Stoner overthrust block is considerably broken up by this fault in the vicinity of Smith Station, and the east side seems to be relatively uplifted, producing the large window in the overthrust at Penn Grove.

GEOLOGIC HISTORY

Pre-Cambrian and Paleozoic time

The earliest known geologic record in York County is preserved in the volcanic rocks exposed in South Mountain and in the Pigeon and Hellam Hills. Because of the existence of older granites and gneisses in Maryland that underlie these lavas, it is believed that the lavas of York County in the areas mentioned above were poured out on a floor made up of similar older granitic and gneissic rocks. The lavas are of two different types, namely rhyolite and basalt, and, from their distribution, it seems that rhyolitic eruptions predominated in the northern part of South Mountain and basaltic eruptions farther south in Pennsylvania. The lava outpouring was accompanied by volcanic ash, thrown out by explosive eruptions. Uplift and erosion took place at the close of pre-Cambrian time after the lavas were extruded.

At the beginning of Cambrian time the region was depressed so that it was invaded by an arm of the sea in which were deposited marine sediments—first coarse waste products from the disintegration of the crystalline rocks, forming arkose, coarse sandstone, and conglomerate; then finer sandy and argillaceous material, forming shale and sandstone. These beds were later hardened into the quartzites, phyllites, slates, and conglomerates, beginning with the Loudoun formation and the Hellam conglomerate member of the Chickies and ending with the Antietam quartzite. Small animals lived in this early sea, for remains of trilobites and shells are sparingly preserved in the calcareous sandstone of the Antietam, and many of the beds of the Montalto and Chickies quartzites have plentiful fossil tubes of the sea worm *Scolithus linearis.* In that part of York County which is now South Mountain, no argillaceous material was deposited with the coarse and fine sands, but farther southeast, in the area of the Pigeon and Hellam Hills, argillaceous silts, which later formed the Harpers phyllite, were deposited between the purer sandy sediments. Still farther to the southeast in the area of York County, the Lower Cambrian sediments were largely argillaceous, with only thin layers of pure sand, forming the Chickies slate and thin quartzite beds which occur south of the Hanover-York valley.

When coarse waste material ceased to be washed into the sea, limy and dolomitic mud and silt were accumulated on the floor of the sea, and were later hardened into limestone, dolomites, and calcareous shales, certain layers of which contain beautifully preserved fossil trilobites and shells, remains of animals that lived in this early sea.

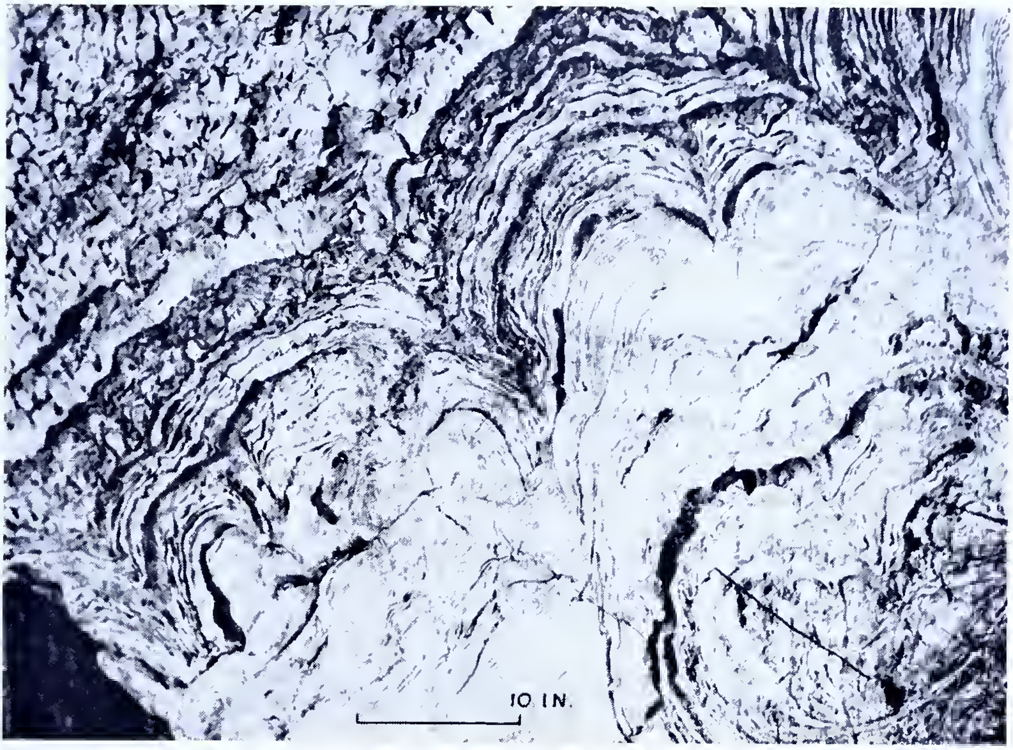
In the region around South Mountain, now the Cumberland Valley, a great thickness of limy deposits accumulated throughout Cambrian and Lower Ordovician time. The land was of low relief, and the streams carried little land waste into the sea, so that calcium and magnesium carbonates, dissolved from the decomposing rocks by rain water, were brought down to the sea and deposited. Much of this calcareous material was extracted from the sea water by algae and other organisms, and deposited on the sea bottom in the form of organic remains. There was a minor elevation of the land area in Waynesboro time, during which red soil, fine siliceous mud, and quartz sand were swept into the sea and deposited as shale and sandstones. Another slight uplift of the land area occurred at the beginning of Conococheague time, when sand grains were carried into the sea and were mixed with the lime silt. In the Cumberland Valley, lime silt continued to be deposited to the close of Lower Ordovician time.

The sea of this area in Cambrian and Lower Ordovician times was inhabited by trilobites and mollusks, and their remains are found in the rocks. Algae also lived on the sea bottom and secreted lime from the sea water, forming beautiful reefs of *Cryptozoons*, now preserved in the limestones (see Pl. 31 A) and other less-definite, wavy, laminated structures in the limestones.

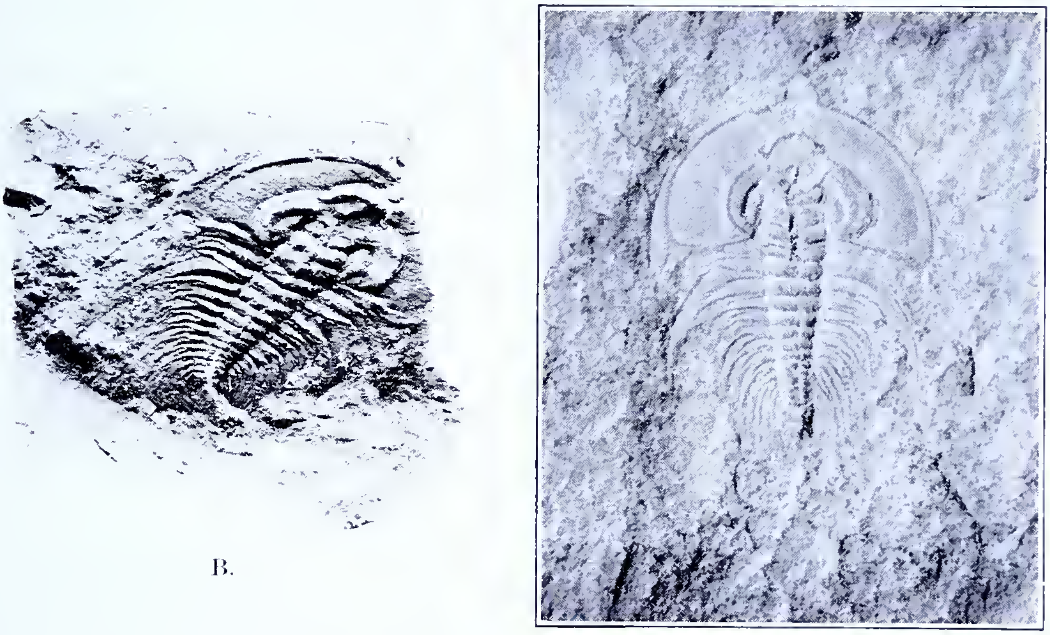
In Middle Ordovician time dark carbonaceous clay began to be deposited in the sea, and a very thick series of argillaceous sediments accumulated, which formed the Martinsburg shale. In northwestern York County local uplift of the sea bottom and erosion of some of the freshly deposited silts preceded the deposition of the Martinsburg shale, for these clayey deposits rest in places on Elbrook limestone where the overlying limestones have been removed by erosion.

In the central part of the county the deposition of carbonate silts in Cambrian time was not as continuous as in the Cumberland Valley. Following the deposition of the Vintage dolomite on the sands of the Antietam, there was deposited a series of clays, sandy beds, and very pure limestone of the Kinzers formation. Trilobites and brachiopods were abundant in the sea at this time, and are more numerous and better preserved in the rocks of the Kinzers formation than in the dolomites that preceded and followed it. (See Pl. 31 B & C.) The purer limestone beds of the Kinzers contain archeocyathid reefs, fossil algae. Pure dolomite followed the deposition of the Kinzers formation, and formed the Ledger dolomite. These carbonate rocks may have been deposited as calcium carbonate and their partial or complete change to dolomite may have occurred at a somewhat later time. Carbonate sediments continued to be deposited during Middle and Upper Cambrian time in Lancaster County, but none of these are known to be preserved in central York County, unless the Conestoga limestone is in part of Upper Cambrian age.

PLATE 31



A. Cross section of a cryptozoon reef from the Conococheague limestone near Clear Springs, Md.



B.

C.

Fossil trilobites from the Kinzers formation in Lancaster County.

The southern part of the region was uplifted in late Cambrian or early Ordovician time, and stood above sea level for a time, during which some of the recently deposited sediments were eroded. When the area was resubmerged, the Conestoga limestone was deposited, and in central York County it lies on Ledger dolomite and Kinzers formation. Farther south, south of the Stoner overthrust, the Conestoga overlaps on to the Antietam quartzite, with the Vintage dolomite and Kinzers formation exposed in a few places. When the sea invaded the area at the beginning of Conestoga time, large and small residual blocks of white marble, that remained on the land surface, were engulfed in the calcareous silt and formed conglomerates in the basal part of the Conestoga. There is no record of later sediments than those of the Conestoga limestone having been deposited in the south-central part of the county.

The history of the southeastern part of the county is not so well known, as no fossiliferous rocks are present in that area to establish a definite time of the deposition of the rocks, which are now largely schists and quartzites. The floor on which these sediments, now schists, were deposited is not seen in the county, but farther to the southeast it is exposed in several upfolds, and is formed of pre-Cambrian rocks similar to the floor on which the pre-Cambrian lava flows of South Mountain were extruded. The earliest deposits in this sea were sandy arkoses, which were followed by limy silt, and this in turn by a thick series of argillaceous and arenaceous sediments, which make up the Glenarm series in York County. In the northwestern part of this basin volcanic rocks intermingled with the calcareous sediments, and pyroclastic material continued to be deposited during the later accumulation of the siliceous and argillaceous sediments. In the southeastern part of the area molten igneous rocks were intruded into the sedimentary rocks. They include gabbro, serpentine, and granites. Of these intrusive rocks, only serpentine is found in York County.

The deposition of the rocks of the Glenarm series, and the igneous chapter in its history, may have occurred in the late part of pre-Cambrian time. It is known to have been before Cincinnatian time, for, in Virginia, uplift and erosion of the Glenarm series and of the granite which intrudes the series preceded the deposition of the Arvonia slate, which is of Cincinnatian age. This slate with a quartz conglomerate at its base, unconformably overlies the Peters Creek quartzite and the granite rocks that intrude it. It is probable that the Cardiff conglomerate and Peach Bottom slate were laid down in the York County area at the same time as the deposition of the Arvonia slate in Virginia.

The rocks of the Glenarm series have been greatly metamorphosed and closely folded, and their present position upon the Paleozoic rocks is the result of overthrusting, which occurred after the Ordovician deposition. The small-scale recumbent folds seen in the rocks of the Glenarm series suggest large-scale recumbent folding during the northwestward transport of those rocks on the Martic overthrust. The trends of the folds in the Paleozoic rocks near the rocks of the Martic overthrust block and of the latest folding in the overthrust block are parallel to the trends in the rocks farther to the northwest, which were deformed in the late Paleozoic orogeny. Hence it is be-

believed that the most evident folding of the rocks in the region of the Martic overthrust is also late Paleozoic in age, and followed the Martic thrusting, which took place probably early in the same period of compression and mountain making.

In late Paleozoic time the pre-Cambrian rocks and overlying Paleozoic rocks in the area northwest of the Martic overthrust were compressed and folded into elongated troughs and arches several thousand feet high and extending many miles in a northeasterly direction. The Hellam Hills and Pigeon Hills and South Mountain anticlinoria are examples of such great arches. Many folds were broken under the intense compression, and some of the breaks culminated in great overthrust faults, such as the Chickies and Glades overthrusts. The folding and compression compacted the sands and muds of the sedimentary series and recrystallized and mildly metamorphosed these rocks, especially in the area south of the Triassic sedimentary rocks. The whole area of York County was later uplifted above the sea and the rocks were exposed to weathering and erosion.

Triassic period

The continental origin of the Newark group is well established by the character of the sediments and their animal life, although sparce. Dinosaurs and crocodiles, whose fossil remains occur in these rocks, were land animals. The phyllopod shells and fish bones and scales that are also found are of animals that lived in fresh water. The irregular bedding that gives rise to wedge-shaped and lenticular layers, and the plentiful irregular cross-bedding in the coarser arkosic sediments are evidences of deposition by torrential streams. The fanglomerate at the western margin of the basin and other coarse conglomerates of unassorted material mark alluvial cones and fans which were formed where streams descending steep slopes debouched on a lowland or into a basin. Evenly bedded shales and sandstones are evidence that such beds were deposited in ponded waters. Ripple marks on the surfaces of the layers indicate that the water was shallow. Sun cracks and rain prints were produced on freshly emerged sediments when exposed by the temporary withdrawal or evaporation of the ponded water, and glauberite crystals were left on the strand by the evaporation of saline waters. The few thin limestone beds and calcareous layers were probably also produced by such dessication. The character of the sediments also indicates a semi-arid climate accompanied by occasional torrential rains, producing temporary flooded conditions and ponding of flood waters. The evidences of dessication mentioned above denote an arid climate. The materials in the sediments are chiefly quartz, feldspar, mica, alumina, and iron oxide. These materials were undoubtedly derived from the disintegration of older quartzose rocks, chiefly Lower Cambrian quartzites and pre-Cambrian crystalline rocks, that were exposed to weathering without erosion for a long period of time. The red color of the sediments is due to the presence of ferric oxide, produced by oxidation without hydration, of the iron content of the distintegrated rock. The presence of abundant sedimentary mica flakes in the rocks of the Newark group shows that crystalline rocks were in part the source of the sediments, and, since these crystalline rocks lie to the southeast, the source of the material was from that direction.

The invariable northwest dip, except at the western margin where the border conglomerate dips east, or where beds are locally disturbed by faulting, of so large a body of sediment can best be explained by a gradual sinking of the floor of the basin in such a way that the center of sedimentation was progressively shifted northwestward. The first sediments would thus be deposited only in the southeastern part of the basin. As the basin deepened to the northwestward, these first deposits would be tilted in that direction by the progressive sinking of the floor, and the next succeeding sediments would be deposited in a part of the basin farther northwestward, overlapping the edges of the first sediments. This progressive sinking of the floor and shifting of the center of deposition northwestward continued until the floor at the western edge of the basin was so sharply flexed that it broke, and sinking progressed by a downward movement of the floor of the basin on a normal fault. This opening in the floor also gave vent to molten diabase from beneath, and this molten rock ascended along this fault fracture in the rock that formed the floor and came up along intersecting joint fractures in the overlying Triassic rocks, and solidified there as crosscutting bodies and dikes. The molten rock also squeezed between layers of the Triassic sediments and solidified as sills. Some of the molten rock may have reached the surface above as lava flows, as it did farther east, but, if so, it has since been removed by erosion. The Triassic rocks at the contact of these molten masses were metamorphosed by the heat of the magma and by accompanying hot water or vapors. The red shales were altered to hard purplish black porcelanite, and red and buff sandstones were bleached white and further silicified. Iron in solution in these magmatic waters was deposited in the form of magnetite in favorable places, chiefly where precipitated by the replacement of lime, and in places combined with lime and silica to form andradite garnet.

It appears therefore that, preceding the Triassic deposition, there existed in this region a wide area of low relief and the rocks at the surface of this plain were subjected to deep weathering without erosion for a long period of time under semi-arid conditions. The crystalline rock disintegrated to its constituent parts, chiefly grains of quartz, feldspar, and mica. The iron was dissolved and redeposited among the particles as ferric oxide, in the absence of sufficient moisture to form the hydrate and in the absence of any large amount of organic matter, as the decomposition of such organic substances would reduce the oxide to a ferrous state. The distintegration of the exposed rocks took place in early Triassic time. In Upper Triassic time, an elongate basin was formed in this plain by subsidence, accompanied by gentle uplift of the area of disintegrated crystalline rock to the southeast. Occasional rains, at first probably gentle, but at times torrential, transported the waste of red-stained debris from the uplifted area northwestward into the basin, where it was deposited as cross-bedded arkose and red sand and red clay. The alternate layering of these materials was probably controlled by the extent of ponded waters, the irregular cross-bedded arkose being deposited by flowing water before ponding and the finer and partly assorted sediments of clay and sand being precipitated in ponded water. The larger lenticular layers of conglomerates were probably deposited by larger streams as alluvial cones and aprons during torrential rains. The layers were probably nearly horizontal when deposited and have since been tilted.

When the floor of the basin sank along the western border fault, the South Mountain area to the northwest was rising, and in the closing stages of the basin filling, streams from this elevated region descended the steep slopes into the basin and deposited alluvial cones of cobble and boulders and red sand along the western margin of the basin. Where the elevation was not so great and the older rocks were still covered with Paleozoic boulders, the streams from the northwest brought down limestone boulders and formed limestone conglomerate along the western border.

Thus the large hills of fanglomerate in Adams County, which just reach the western edge of York County, were alluvial cones of large streams that descended the steep slopes of the uplifted South Mountain area and emptied into the basin in the closing stage of the basin filling. The coarse beds of the Conewago Mountains were similarly deposited at an earlier stage by a large torrential stream that dumped this coarse material in the basin at this point, while finer material was being deposited elsewhere in the basin by smaller streams that emptied into quiet waters.

Post-Triassic time

Since Triassic time the area has been continuously above sea and has received no deposits, except alluvium along the larger streams, but, on the other hand, the land has suffered erosion of its exposed rocks, which have been gradually worn down and the waste removed to the distant sea. At the beginning of Cretaceous time all the rocks, including the hardest and most resistant, were worn down to a nearly level, gently rolling surface near sea level, called the Schooley peneplain. At the beginning of Tertiary time this surface was raised and was again subjected to erosion. Much dissected remnants of this surface are preserved in the Pigeon Hills at 1,140 feet altitude, and in the southern part of the county at about 1,000 feet altitude. The rolling upland in the southern part of York County attains a rather uniform level about 900 to 1,020 feet in altitude, with a few points 20 to 40 feet higher. This flat upland surface is best shown at Shrewsbury, Mt. Airy School, Mt. Olivet Church, and the hilltop southeast of Winterstown. The flat top of the latter hill is 1,020 feet in altitude and is nearly ½ mile square. The flat hilltop in the vicinity of Mt. Olivet Church is 1,000 to 1,020 feet in altitude, and extends almost continuously for over 2 miles in a north-south direction. Smaller flat uplands at this general level occur on Rocky Ridge, Dug Hill and its extension southwest of Sticks, and the hill in the northern part of the Wentz syncline southwest of Beecher Hill. These flat surfaces probably represent the Schooley peneplain, and are believed by the writers to have been little reduced since they were formed. The flat hilltops that stand at 900 feet, or somewhat less, have been reduced in elevation

100 or more feet. Ashley[17] thinks that such mature surfaces have been greatly reduced by erosion and weathering, maybe 1 foot in 10,000 years time, but still preserve their level character.

The Pigeon Hills, 10 miles north of the hills of the Wentz syncline, rise to elevations of 1,000 to 1,240 feet. A rather flat bench at 1,140 feet probably represents the Schooley peneplain, and is 120 feet higher than the Schooley level in the southern part of the county, 10 miles to the southeast. Two rocky peaks that rise above this bench are monadnocks on the Schooley surface. The Schooley surface, therefore, slopes about 120 feet in 10 miles, or 12 feet to the mile, in this part of the county. Flat tops of ridges, in South Mountain, Adams County, 20-25 miles northwest of the Pigeon Hills, rise to an altitude of about 1,600 feet, but they are not as extensive as the broad flat top of the mountain, called Big Flat, farther south, whose altitude is 2,050 feet. This flat surface is regarded by the writers as a remnant of the Schooley peneplain. The marked discrepancy of this elevation with that of the Schooley peneplain on the Pigeon Hills and area to the southeast has been explained by Stose[18] as due to post-Cretaceous faulting.

By the close of the Tertiary the surface of the softer rocks was again reduced to a gently sloping, nearly level plain, and remnants of this surface, called the Harrisburg peneplain, are preserved at 620 to 520 feet altitude. The flat-topped hills on the Triassic sandstones and shales in the northwestern part of the Hanover quadrangle, which range in altitude from 520 to 560 feet, probably represent the Harrisburg plain. The limestone in the flat lowland around Hanover is deeply weathered and almost no outcrops occur, indicating long exposure to weathering without much reduction of level by erosion. This lowland, which is from 600 to 620 feet in altitude and which forms the divide between streams that flow eastward into the Codorus and westward into the South Branch of the Conewago, probably also represents the Harrisburg plain.

The present mountains, valleys, and lowland have been sculptured out of these uplifted surfaces.

MINERAL RESOURCES

The chief mineral resources of York County are limestone and roofing slate. Limestone is extensively quarried for lime burning, flux, cement manufacture, and crushed stone. Slate is quarried at Delta, and has been prospected at several other places. Iron ore was mined extensively decades ago, but no mines are working at present. White paper clay has been mined in South Mountain and mining may be resumed. Sand and clay are dug locally for building purposes and brick manufacture. Many of the rocks in the county are used locally in building dams, bridge piers, retaining walls, and stone fences, and in the past some stone was used for building houses.

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[17] Ashley, G. H., Weathering and erosion as time markers: Read before the Geol. Soc. Amer., Dec. 1937, Abstract, Proc. Geol. Soc. Amer. for 1937, p. 70, 1938.

[18] Stose, G. W., Possible post-Cretaceous faulting in the Appalachians: Geol. Soc. America. Bull., vol. 38, pp. 493-504, 1927.

High-calcium limestone

Limestone of unusual purity and high-calcium content occurs in the middle member of the Kinzers formation. This pure rock occurs in restricted areas in the York Valley from York to Thomasville. Elsewhere the rock is not so pure, or the pure beds are thin. In the York Valley the limestone is largely concealed by residual clay, and the extent and thickness of the pure rock can be determined only by stripping or drilling. The limestone weathers readily and forms a very humpy surface beneath the residual soil. (See Pl. 32.) The area underlain by the middle member of the Kinzers formation, which carries the pure beds, is indicated on the geologic map.

In early days the pure high-calcium rock was quarried extensively in the city of York and vicinity, but most of these quarries have ceased operation because of city growth. It is now quarried actively in the area by four companies. For detailed description of these and other quarries in the area, as well as the technology of the limestone industry, the reader is referred to a comprehensive report on the limestones of the State by Benj. L. Miller.[19] The product is used for whiting, portland cement, flux in the steel and glass industries, and, either raw or burned, as fertilizer.

The Universal Gypsum & Lime Co. plant, formerly operated by the Palmer Lime & Cement Co., is in the southern part of West York, on a branch of the Pennsylvania Railroad. The rock in the large quarry varies from a compact dark siliceous rock with dolomite mottling at the base, said to run 28 percent $Mg.CO_3$, to a purer white marble with gray mottling above, said to run 18 percent $Mg.CO_3$, and to a still purer compact white marble which is reported to run 98 to 99 percent $Ca.CO_3$. This grades at the top into gray, mottled or spotted calico rock, higher in magnesium. (See Pl. 33.) The large quarry south of the plant is about 1,000 feet long by 600 feet across, with a 50-foot face. Radiate tracks converge to the incline tram leading to the crushing plant. There are 2 crushing and pulverizing mills and 10 vertical steel kilns. The newer quarry, northeast of the older quarry, is reached by tunnels under the roadway from the old quarry, and high-grade rock beneath the plant is also reached by tunnels. The high-grade rock is carefully hand picked and is in part burned for lime. Some is crushed and pulverized raw.

The Thomasville Stone & Lime Co. has a large quarry and plant ½ mile south of Thomasville, on the Western Maryland Railroad. The quarry is about 1,000 feet long with a semi-circular face about 50 feet high. The beds lie nearly horizontal, and have been tested by drill to a depth of 200 feet. The rock in the quarry is a high-calcium limestone, and the same quality is reported to extend to a depth of 100-150 feet below the floor. One shipment of 40 carloads of select crushed rock was reported to average over 98 percent $Ca.CO_3$, and a 10-carload shipment to the Midvale Iron and Steel Co. was reported to have analyzed 99.69 percent $Ca.CO_3$. Some of the rock is burned for lime and some is granulated and pulverized for steel and glass

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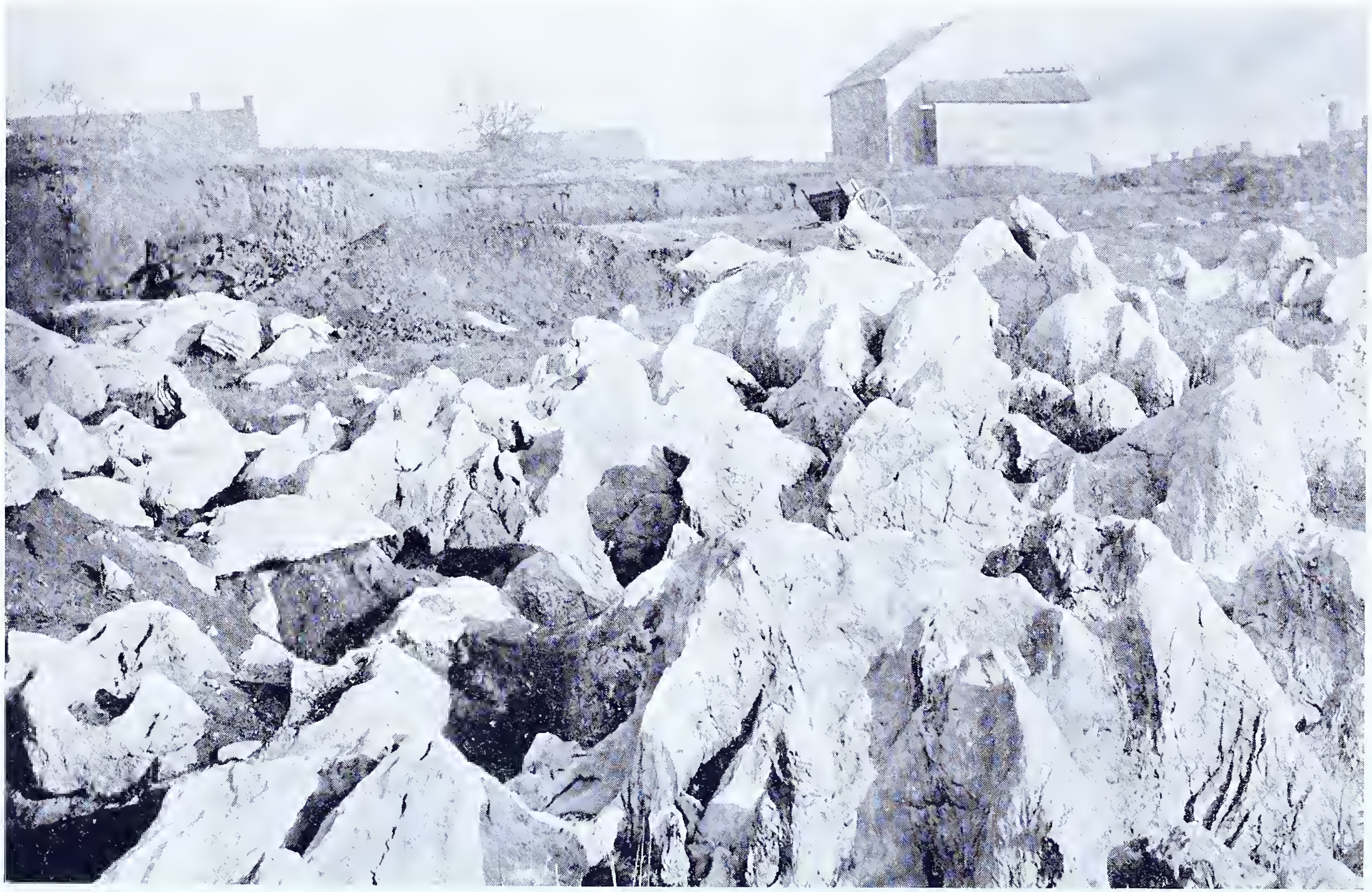
[19] Miller, B. L., Limestones of Pennsylvania: Pennsylvania Geol. Surv. 4th ser., Bull. M 20, pp. 9-112, 702-712, 1934.

PLATE 32



Stripped limestone, showing pinnacled surface due to subsurface solution.
Quarry in eastern part of York. (Photograph by C. D. Walcott.)

A. Quarry of Universal Gypsum & Lime Co. in West York.

B. Calico rock, magnesium mottled limestone, at top of quarry of Universal Gypsum & Lime Co.

plants. The less-pure rock is crushed for road material. The equipment consists of 2 well-drilling rigs, 1 stripping shovel, 3 loading shovels, crushing and pulverizing plants, and 14 vertical steel kilns. Radial tracks converge to the incline tram to the crushing plant.

The J. E. Baker Co. has a large quarry and plant just south of Thomasville, and another quarry north of the Lincoln Highway at Thomasville, but the latter was closed when visited in 1937. Incline trams lead from both quarries to the crushing plant. The high-grade rock is burned for lime in 8 steel kilns, and some is pulverized raw. Less-pure rock is crushed for road material. Nests of quartz in fine needle-like crystals (Pl. 34 A) occur in the limestone in places. This company also has a quarry in similar high-grade rock 1½ miles west of West York, south of the Sandusky Cement Co. quarry.

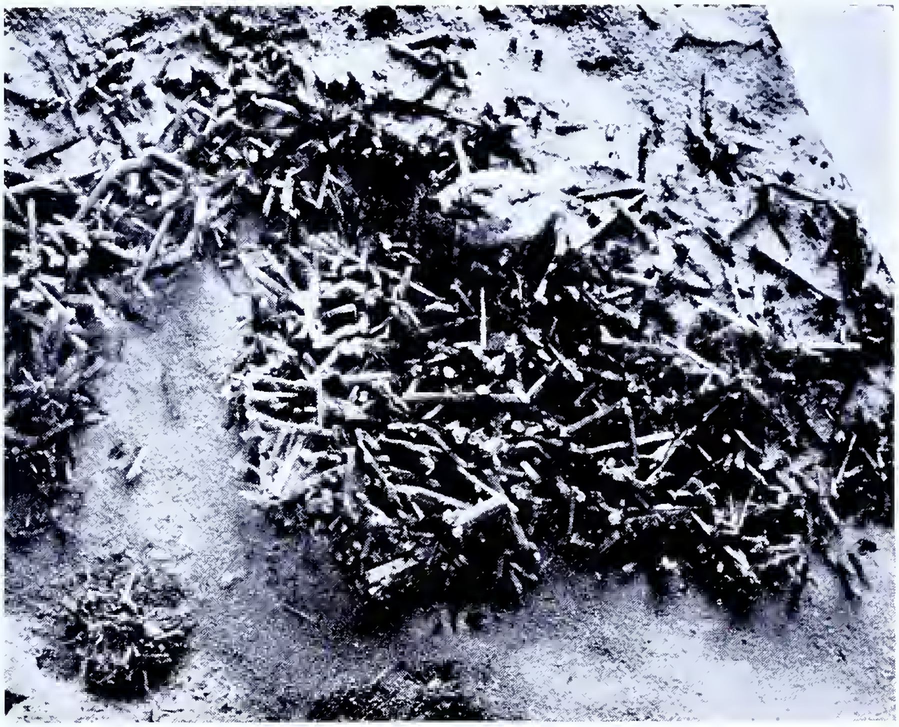
The Sandusky Cement Co., formerly the Medusa Portland Cement Co., has a large quarry and plant 1½ miles west of West York, reached by a spur from the Western Maryland Railroad. The rock is a high-calcium gray to white marble in the middle member of the Kinzers formation. The quarry is about 300 feet in diameter with 40-foot face. A concrete tower and storage bins and the crushing plant are reached by inclined tram from the quarry floor. The crushed rock is conveyed by rail to the cement mill at West York where Medusa white and gray portland cements are produced in a long rotary kiln. The product is stored at the mill in 2 large vertical concrete bins.

At Saginaw, near the Susquehanna River, the Mount Wolf quarry, which is on a spur of the Pennsylvania Railroad freight line, is operated by J. E. Baker & Co. It was formerly the Codorus plant of the Union Stone Co. The quarry is about 1,500 feet long parallel to the strike and 1,200 feet wide. The northwest side has a 65-foot face, where the rock dips 45°NW. The water pump and air drills are operated by an Ingersoll-Rand compressor. Horse-drawn cars operate on tracks on the floor of the quarry to take stone to the inclined cableway. Both high-calcium, low-silica limestone and low-silica dolomite are burned in flame kilns, the former for flux and the latter for plaster, agriculture, chemical industries, and furnace lining. Some of the rock is crushed for road material. Both gyratory and disk electrical crushers are used to produce three sizes of road material.

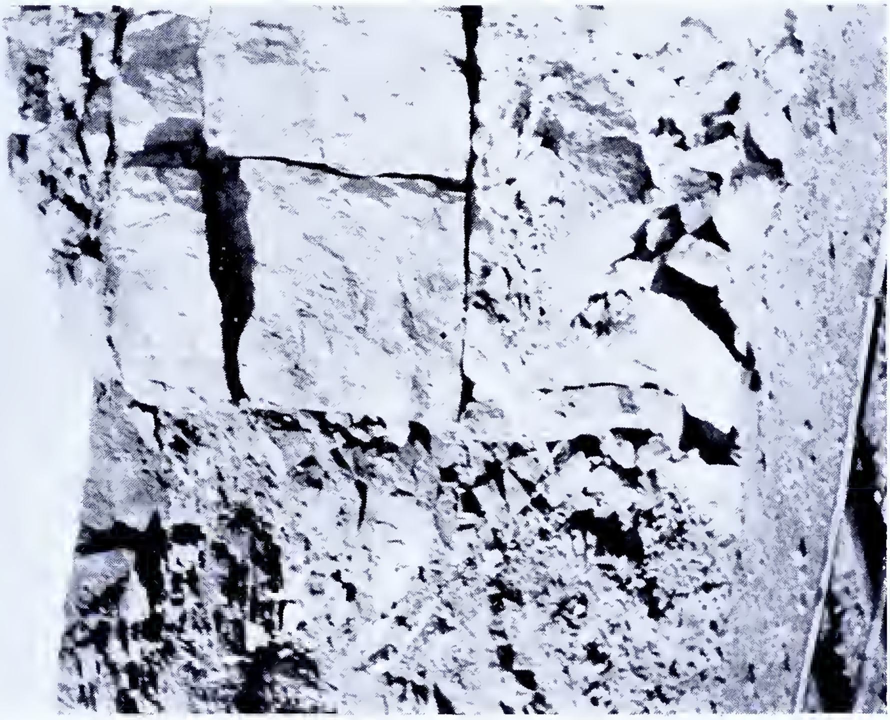
Limestone

Less-pure limestone and dolomite are burned for lime and use on soils, some is ground and pulverized raw, and some is crushed for road material and concrete. Many small abandoned quarries, where lime was formerly burned for local use to sweeten acid soils, occur throughout the area where limestone is exposed. Only the larger recently active quarries will be described.

The Eli Zinn Co. has two quarries in operation for crushed stone in the vicinity of York. Their largest quarry is in pure and overlying impure dark-blue slaty limestone of the middle and upper part of the Kinzers formation, on the south side of Highland Park Hill at Codorus Creek, south of York. The quarry is about 200 feet long and has a



A. Nests of needle-like crystals of quartz in the limestone at the quarry of the J. E. Baker Co., Thomasville.



B. Face of quarry of Roy Bittinger Co., Spring Grove.

Showing horizontal dark argillaceous limestone dropped by a vertical normal fault against massive limestone of the middle member of the Kinzers formation. Fossil trilobites were collected from the dark limestones at the left.

face about 100 feet high. The other quarry is in pure limestone and marble of the middle part of the Kinzers formation on the northeast slope of Greenmount Cemetery Hill. Both quarries are equipped with crushing plant, screens, and storage bins, and the product is hauled by truck.

The York Stone & Supply Company has two quarries on the east face of Greenmount Cemetery Hill in pure limestone of the middle member of the Kinzers formation. The rock is crushed for road material. Sandy beds at the top of the old deeper quarry are fossiliferous.

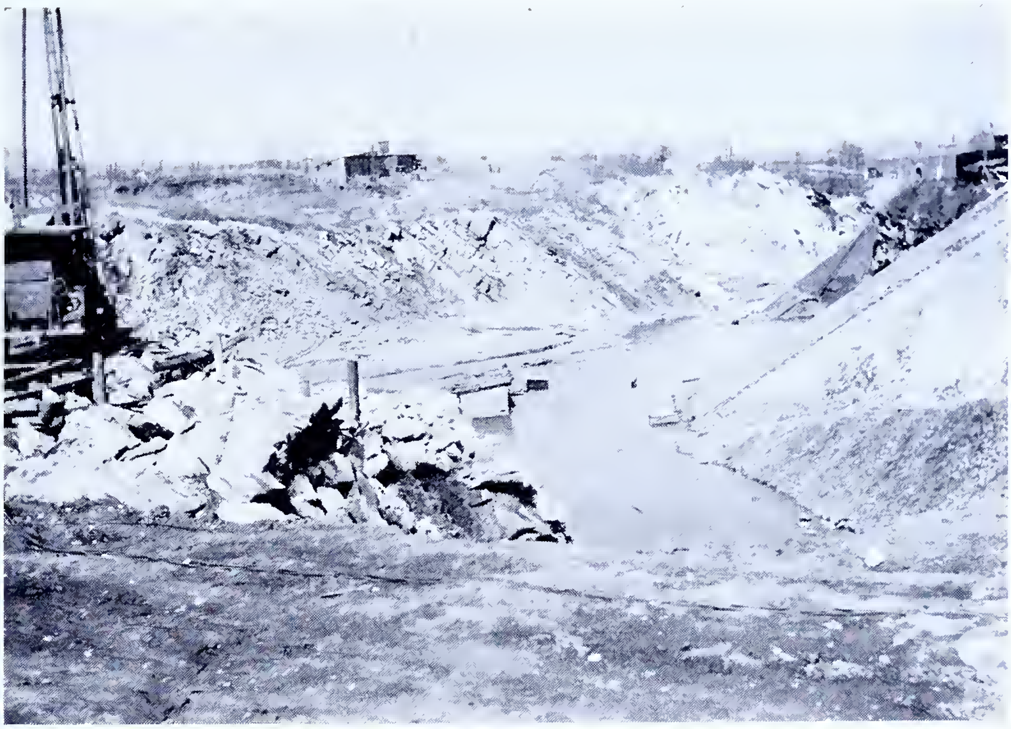
The Roy Bittinger Company has a quarry for crushed stone in the southwestern part of Spring Grove adjacent to Codorus Creek. The rock is thin-bedded argillaceous limestone and massive limestone of the Kinzers formation. Faults and other structural features in this quarry are shown in plate 34 B. Some of the beds contain fossil trilobites.

The Standard Concrete Products Co. operates a quarry in banded limestone and dolomite of the Vintage formation northeast of York. near Mill Creek. The rock is crushed and ground, and is used in the manufacture of concrete building blocks. The Cunningham Crushed Stone Co. has a large quarry in massive Ledger dolomite across the road to the east, but it was idle in 1937.

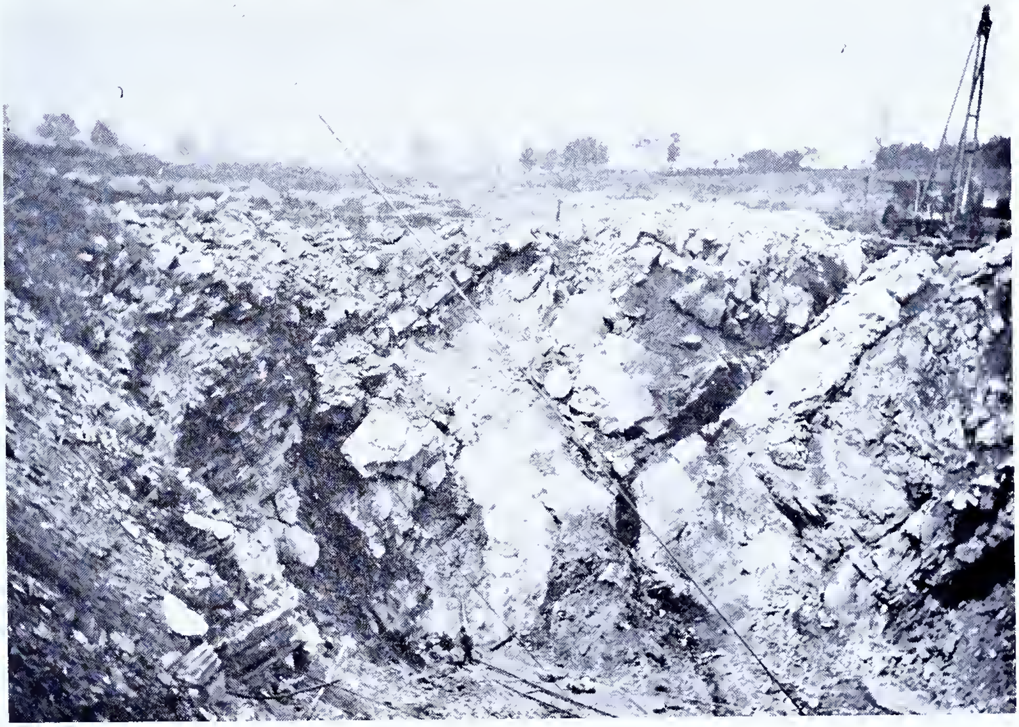
The York Valley Lime & Stone Co. quarry is adjacent to the Lincoln Highway, U. S. 30, north of Campbell. (See Pl. 35.) It is connected with the Pennsylvania Railroad by a privately owned narrow-gauge railroad. The rock is largely limestone conglomerate, white marble, and impure slaty limestone of the middle part of the Kinzers formation, and was used chiefly for crushed stone for highway construction. An inclined steel-car cable tram leads from the radial tracks in the quarry to a high crushing plant with concrete bins above the loading tracks. Steam shovel was used for stripping, and there were 2 well-drilling rigs. Steam drills were used in the quarry. The product was shipped by rail and by trucks. Formerly the purer rock was burned for lime in 12 kilns located south of the highway, but these have not been in use for several years. The quarry was operated for a time by the U. S. Gypsum Co., but was idle in 1937. A fault in the quarry is shown in plate 28 B.

The A. M. Hake & Co. formerly quarried stone in the northeast part of York, but the quarry has been encroached on by the extension of the city, and is abandoned. The deep hole of the old quarry is filled with water and used as a dump for rubbish.

The Susquehanna Stone Co. opened a quarry in 1929 in the Vintage dolomite just south of Wrightsville, and crushed stone was obtained for road material and concrete in the construction of the new highway bridge over the Susquehanna River between Wrightsville and Columbia. Crusher, screens, elevator, and large elevated bins were installed, and the quarry and plant were operated by electricity. The rock is a dense homogeneous fine-grained blue dolomite of the Vintage which



A. Quarry of the York Valley Lime & Stone Co., 6 miles northeast of York. Looking east.



B. West end of quarry of the York Valley Lime & Stone Co.

Showing thick-bedded limestone of the middle member of the Kinzers formation. Fossils were obtained in overlying argillaceous beds at the top of the quarry, at the left.

crushes to angular pieces suitable for concrete. Several old large quarries were located north of Wrightsville.

In the limestone area north of the Triassic basin, in part in Cumberland County, there are several centers of quarry activity. The largest quarry is that of Strayer and Lefever Bros., ½ mile southeast of Williams Grove near the county line. (See Pl. 15 B.) This quarry is in Tomstown dolomite and the face is capped by Waynesboro formation. The rock is massive gray dolomite, well suited for road material. The curving quarry face is about 700 feet long and 60 feet high. The rock is blasted to the floor of the quarry and trucked to the crushing plant. Delivery to consumers is by truck. There are several old small quarries in the same rock exposed along the strike of the beds to the south.

Triassic limestone conglomerate has been quarried at several places in the county. The largest quarry formerly operated by John Kuntz, is 1¼ miles west of Dillsburg at the foot of the slope of South Mountain. Here about 50 feet of conglomerate is exposed. Thinner and less-pure limestone conglomerate was quarried at the roadside ½ mile southwest of Dillsburg, and also half a mile northwest of Uniontown. A limestone conglomerate bed about 25 feet thick interbedded with red sandstone was reported quarried many years ago in the vicinity of Lisburn. Some of the limestone boulders in the conglomerate were 2 feet across. This limestone conglomerate is exposed in the banks of Yellow Breeches Creek and along the Lisburn highway east of the creek. An impure limestone conglomerate half a mile north of Bunches was also quarried many years ago, but it contained a large amount of sandstone, shale, chert, and schist, so that the burned product was probably one-half silica or insoluble material, but was suitable for limey clayey soils.

Roofing slate

Roofing slate of high quality is produced in the Peach Bottom district, part of which is in the southeast corner of York County. Peach Bottom slate is noted for its quality, and there was formerly a large slate industry in the county. The slate industry in the Peach Bottom district is fully described in a recent report by Behre,[20] and details will not be given here.

Only one plant is now in operation in the county. The Funkhauser Company of Hagerstown, Md., is quarrying slate at the old Johnson quarry, 2 miles northeast of the State line at Delta. This was originally 3 separate quarries which have now been united into one large ramifying open cut, over 1,000 feet long. (See Pl. 36 and 19 B.) Mining has been extended northward by tunnelling at the floor level. Most of the product is hauled to the mill at the railroad north of the quarry by gasoline engine, where the slate is crushed for roofing granules. The slate dust and fines is used for filler. High-grade roofing slate is also produced. The old Humphreys quarry, about ½ mile to the southwest, is also operated at present by the Funkhauser Company. This is one of the largest of the old quarries and

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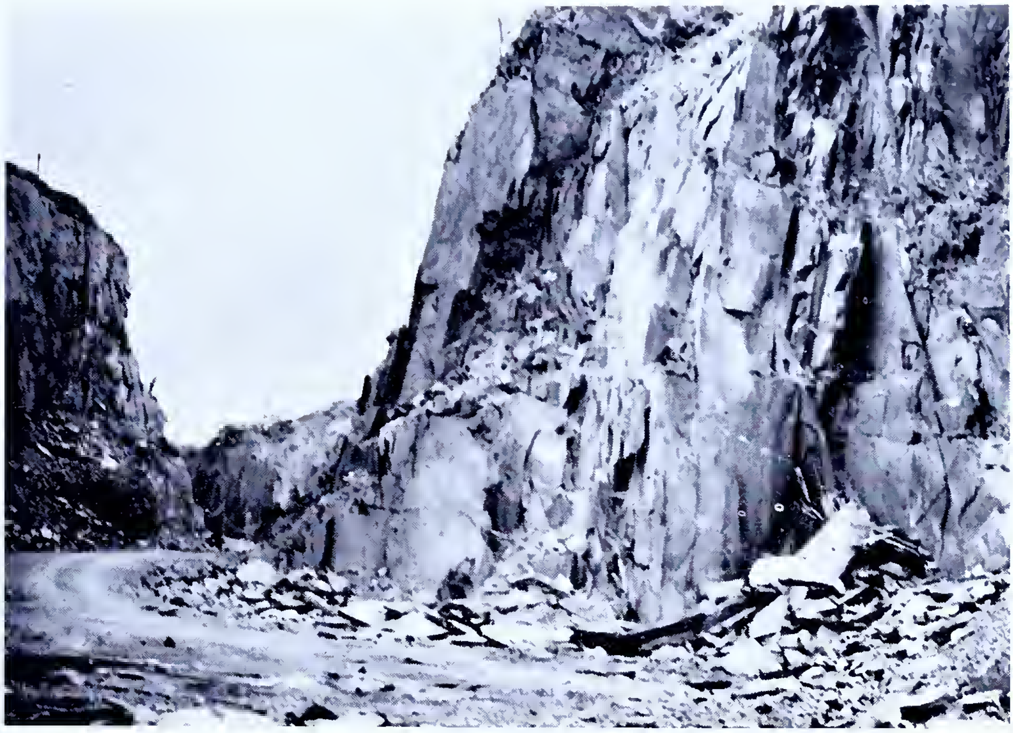
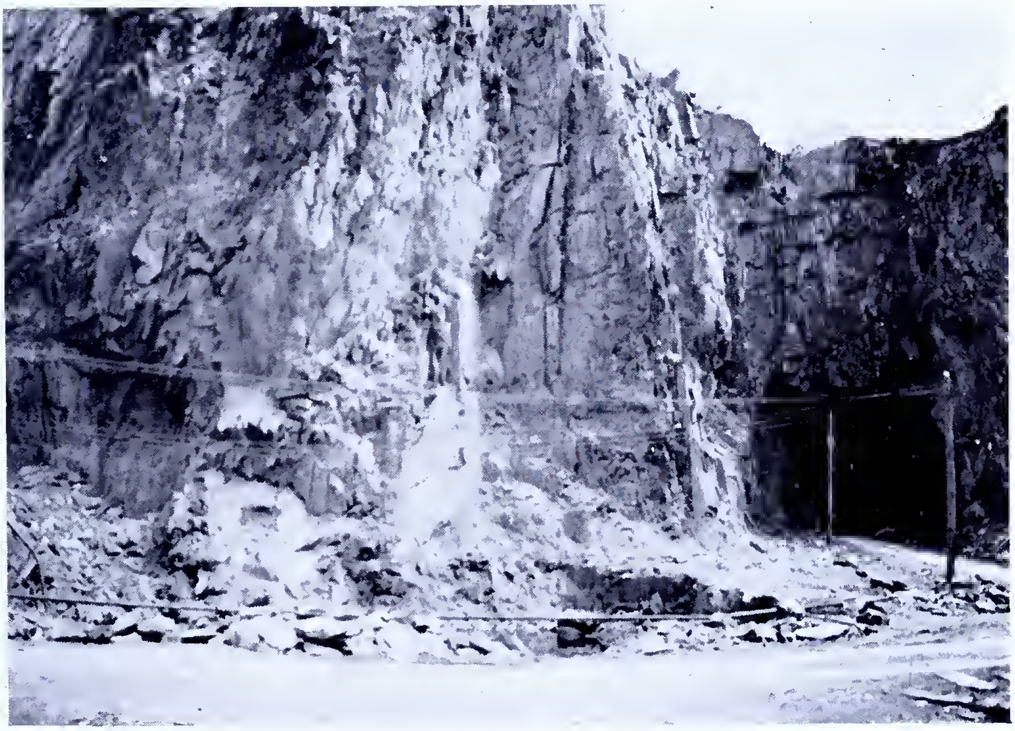
[20] Behre, C. H., Slate in Pennsylvania: Pennsylvania Topog. & Geol. Surv., Bull. M 16, pp. 359-390, 1933.



A. Funkhauser slate quarry, looking north toward entry.



B. Funkhauser slate quarry, near entry, at left, and tunnel at right.
Showing probable bedding dipping low to left.

is 960 feet long, 120 feet wide, and 200 feet deep, according to Behre. The quarry was first opened in 1860, and has been operated at intervals ever since. Roofing slate is obtained here, and grave vaults, steps, and other sawed mill products were formerly also produced.

Slate has been quarried in Pennsylvania since 1749, but the industry did not become active until 1847 when Welsh methods were introduced south of the State line. The quarries in existence in 1898 are described by Matthews.[21] The Stasco Milling Co. is alone actively quarrying at present in Maryland. They are operating an old quarry east of Whiteford, north of the east-west road, and the crushing plant is at the north-south highway, south of Whiteford, where slate granules are produced. The quarry exhibits folds of the original bedding which are cut by the cleavage. (See Pl. 20.) Similar bedding "joints" were clearly shown in a photograph of the slate in the Proctor Bros. quarry, farther south, illustrated by Mathews.[22] (See Pl. 19 A.) The importance of these clearly preserved folds is described under structure.

Slate of good quality is not exhausted in the old abandoned quarries, but whether it can be profitably mined under present conditions depends on the cost of operation at increasingly greater depth in open cuts or by underground workings. The high-grade roofing slate seems to occur in the center of tightly compressed synclines. Whether this is due solely to the character of sedimentary layers, whose composition is such that a smoothly splitting slate is produced under pressure, or whether the controlling factor was the position in the center of the syncline where pressures were nearly equal and uniform, is not known. As shown in figure 5 the quarries are located along 3 belts which mark the axes of synclinal folds. The lower beds of the formation are tough and do not split into good roofing slate. (See Pl. 37 A.)

Slate has been prospected at several other places in the county but none of roofing quality has been obtained outside of the Peach Bottom district. One mile southwest of Kinney school, north of Brodbecks, a quarry 20 feet deep in the Marburg schist exposes black to gray smooth-splitting slate. Large slabs or plates were also once quarried here for mill products. Half a mile east of Zumbrum School similar slate from the Marburg schist was prospected for roofing slate. Slate has been quarried also at several places in the Chickies slate south of the York valley. The product was not satisfactory and the operations were abandoned.

Black slate was quarried from the Chickies slate just south of Plank Road, but the slate proved to be too fissile for roofing purposes. Two quarries for slate were opened by L. P. Litsiner of York on Kreutz Creek southwest of Yorkana. In both quarries thin quartzite layers are interbedded in the black slate.

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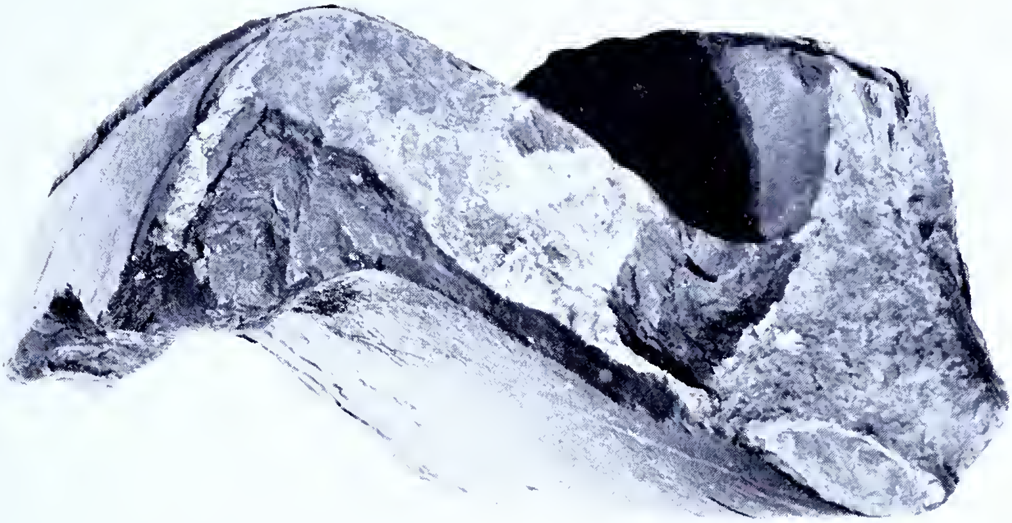
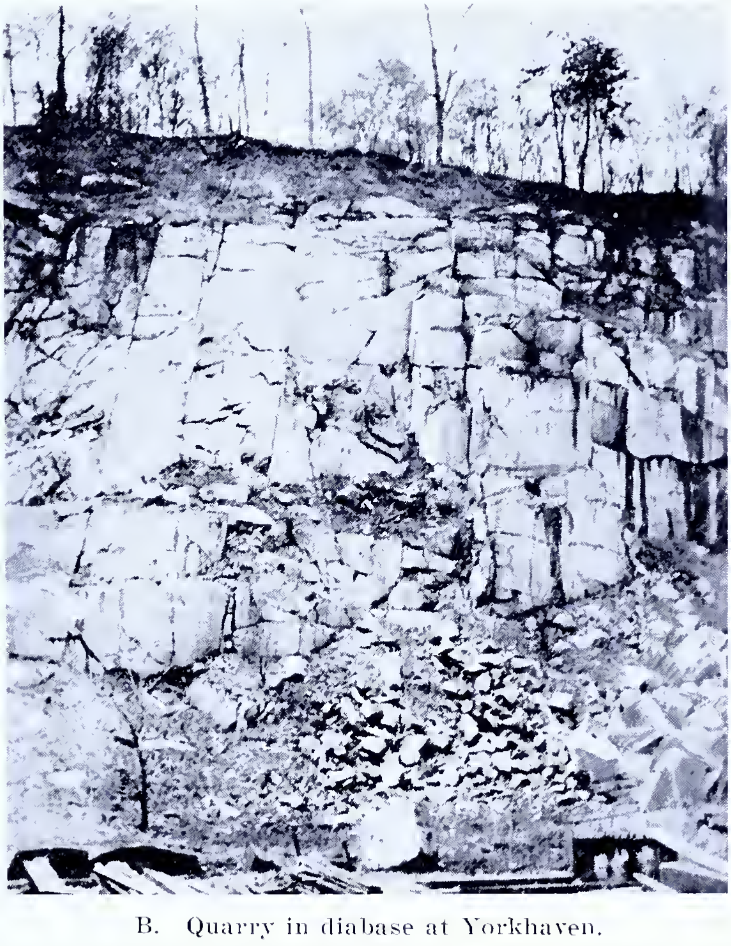
[21] Mathews, E. B., Maryland Geol. Surv. Annual Rept. vol. 2, pp. 214-232, 1898.

[22] op. cit., p. 216.



A. Folded layer of tough sandy slate near base of the Peach Bottom slate, northeast of Slate Hill.

Quartz vein on joint, at right angles to the fold axes.



B. Quarry in diabase at Yorkhaven.

Large mill blocks were quarried here for retaining walls at the Yorkhaven hydro-electric plant.

White paper clay

Highly siliceous sericitic white clay, suitable for filler in paper and paint manufacture, is associated with limonite in the iron mines in Dogwood Hollow. In 1907 the Dillsburg Vitri Brick Company mined the clay in connection with the mining of iron by the Juniata Furnace & Foundry Co. The mine was located at the foot of the steep slope of the mountain on the north side of Dogwood Hollow 3½ miles west of Dillsburg near the county line. It was reported that 75 feet of white clay was passed through by the 275 feet incline, which sloped 30° into the mountain. More recently the Mineral Products Co. of Dillsburg has operated the clay mine. The shaft was sunk in an old iron pit 50 feet deep, the bottom of which was about 75 feet above the valley floor. Yellow and white clay are exposed in the old iron pit. A narrow gauge tram road carried the product from the tipple to the plant west of Dillsburg, which was equipped with washers, driers, and filter presses. The mine was closed when visited in the spring of 1938, but it was reported that mining would be resumed with Lancaster capital.

The clay is similar to that which has been extensively mined in the vicinity of Mt. Holly Springs, in Cumberland County, described by Stose.[23] The white clay is believed to have been derived from disintegrated sericitic fine-grained quartzite at the top of the Antietam, but some of it may have been transported and redeposited with the residual iron ore. The thickness and extent of the deposit is not known, but it is probable that a considerable quantity of unmined white clay remains.

The sericitic rhyolite schist in the western corner of York County and adjacent parts of Cumberland County has been prospected for white clay. The Sprenkle Clay Co. of Latimore opened a mine in a greenish sericite schist and purplish clay derived from a purple schist in the lowland southeast of Long Mountain. A refinery was built and some white clay was produced. The product was not satisfactory, probably because of the presence of quartz grains in the schist, and the plant was abandoned.

The deposits of white paper clay in the South Mountain area have not been exhausted but whether the clay that remains is of sufficient body to be worked economically at the present labor costs must be determined by boring or prospecting.

White sandy sericitic clay has been dug at the Cooper quarry, half a mile south of Highmount, on the north side of the road to Accomac. It is derived from a soft fine even-grained sericitic sheared quartzite or quartz schist in the upper part of the Chickies quartzite. The product was used by the Foundry Supply Co. of Stoner Station to make molding sand, and some crude clay was shipped.

Brick clay

Bricks are made from clay residual from impure limestone and from ground shale and slate. There are several brick plants in the outskirts of York, two of which, within the built-up part of the city, are now abandoned. The Wm. H. Grothe Brick Co. plant is southeast of the city, south of the East Prospect road. Here a large area has been stripped, exposing closely folded, hard crystalline impure Conestoga limestone. (See Pl. 16.) Some layers 20 feet wide, composed of very impure schistose limestone, are deeply weathered to a sericitic clay, and these beds are the chief source of the clay. The plant has a long drying shed and 3 Dutch kilns.

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[23] Stose, G. W., White clay of South Mountain, Pa.: U. S. Geol. Surv., Bull. 315, pp. 322-334, 1907.

The Spring Garden Brick Plant, east of York on the Maryland & Pennsylvania Railroad uses a residual clay overlying disintegrated Conestoga limestone. It is equipped with 6 beehive kilns and a long drying shed. It produces chiefly a dark-red building brick called colonial.

Brick was formerly produced from ground slate 1 mile southeast of Spring Plains. The quarry was in Chickies slate in the hills south of the plant, reached by a railroad spur that connected with the Pennsylvania Railroad east of Spring Plains. The deep quarry is filled with water and the plant and railroad track are now dismantled.

South of Hanover brick was made from soil residual from weathered shale of the Kinzers. The pit was 400 feet long and 15 feet deep. This plant is dismantled and the pit abandoned.

Brick is also produced from disintegrated Triassic rocks 2 miles south of Manchester. The clay is derived from a 20-foot bed of red shale of the New Oxford formation, which dips 10°-20° N. under an arkosic sandstone. The clay has been removed from a pit about 1,000 feet long and 100 feet wide. Wire-cut brick was produced here by the Manchester Shale Brick Co.

The Peerless Brick Co. has a plant on Codorus Creek just below the Elmer King sand quarry, north of York. White sand obtained from the Chickies quartzite by crushing is mixed with clay from elsewhere and a smooth white compressed brick is made. Lime-sand brick is also produced. The plant was not in operation at the time of visit in 1937.

Building sand

Sand is obtained in the county chiefly from disintegrated quartzite and by crushing harder beds of quartzite. Some is also obtained from residuum from disintegrated highly sandy limestone.

The only active sand operation in the county is at the quarries of Elmer B. King and Bro. and the Neuman Sand & Supply Co. in the gorge of Codorus Creek, 2 miles north of York. Two quarries are opened in the Chickies quartzite above the Pennsylvania Railroad, and the product is brought by gravity to the crushing plants at the railroad. The lower quarry is about 20 feet wide and has a 30-foot face. The upper, larger quarry has a length of about 300 feet into the hill and a 40-foot face. The rock is crumbly, thin-bedded, gray to purplish quartzite, weathered rusty, with some harder vitreous beds. The rock is crushed, ground, and screened, and delivered to storage bins above the loading platform. The product is loaded into cars and trucks by gravity.

Sand from disintegrated white arkosic quartzite of the Hellam member of the Chickies has also been dug on Mt. Zion Hill southeast of

Pleasureville. The quarry was operated by W. J. Herman, and considerable sand was dug from a pit 12 feet deep. Disintegrated quartzite beds in the Chickies slate south of the York valley has been quarried on the Dallastown pike 2½ miles southeast of York. Clay also was obtained at this quarry. Another old sand pit in this quartzite is on the top of Violet Hill 1 mile south of the reservoir south of York. This pit exposes much crushed and brecciated schistose quartzite, deeply stained with iron and injected with quartz veins, and marks a fault fracture. Sand was also dug from disintegrated quartzite in the Marburg schist, 1½ miles east of Red Lion. Disintegrated Triassic diabase is a source of sand on State Highway 194, 2 miles south of Kralltown.

The Hershey Sand Co. has a pit in disintegrated sandy limestone in the northeastern part of Hanover. Here very sandy limestone beds in the Conestoga limestone disintegrate into a ferruginous sand, which is dug and screened and used for building sand. (See Pl. 17.) The quarry was inactive in 1936, except for desultory hand screening of loose material. This is the same horizon in the Conestoga limestone that is more extensively exploited near McSherrystown in Adams County.[24]

Stone

Quartzite is quarried for building purposes in many places in the vicinity of York and Hanover. The thinner-bedded rock splits into rough slabs of suitable size for foundations, bridge piers, and walls. Such stone has been obtained at several quarries on the south slope of the Pigeon Hills north of Hanover and at two places west of Spring Grove. The latter quarries are the largest stone quarries in the area. Similar stone has been quarried on the south slope of Mt. Zion Hill, northeast of York.

Stone is also obtained from quartzites in the Chickies slate at 2 quarries near the York and Winsor Electric Railroad, 1 mile southeast of Violet Hill, and on Mill Creek near Benroy. Blocks are obtained for foundations, and some rock was crushed for concrete and road material.

Quartzite beds in the Marburg schist have been quarried 1½ and 2½ miles southwest of Red Lion and 1½ miles southeast of Red Lion. Quartzite was also quarried half a mile northwest of Brodbeck, probably for bridge piers. The Antietam quartzite has been quarried locally for building stone 1 mile, 2 miles, and 3 miles south of Pennville, in the western part of the county. It has also been quarried, probably for road material, near the head of West Branch of Codorus Creek southeast of Krentler School and near Cold Spring 1½ miles northeast of Jefferson.

Limestone has been used for foundations of buildings, bridge piers, walls, and stone fences, and in pioneer days many houses were built of it. The mill at New Market is built of limestone. Metabasalt was locally quarried for bridge piers just south of Seitzland.

Red sandstone of the Triassic, or "Brownstone" as it is known in the market, is plentiful in the Gettysburg shale area shown on the map, and has been quarried locally for foundations and building stone throughout the county. The best stone is reported to occur in the vicinity of Yocumtown, Newberrytown, and Goldsboro, which are not far from the noted quarries of this rock at Hummelstown, Dauphin County. Two large old quarries 1 mile southeast of Yocumtown were operated by a Mr. Rheeling between 1850 and 1880, and a large quantity of high-grade stone was taken out. About 15,000 cubic feet of stone a year was produced during this period. A massive bed 12-15 feet thick between softer red shales was the main quarry rock.[25] Many houses in the larger cities were built of the rock from this quarry, but it is not a popular building stone now. The rock was also quarried for local use on the Rheeling farm, 2½ miles north of Goldboro. Brownstone was quarried for flagstone by C. M. Hess on Conewago Mountain south of the Wellsville road, and for building stone ¾ mile northwest of Wellsville.[26] Gray sandstone was quarried for local use at Bensels Mill on Little Conewago Creek, 3½ miles northeast of Dover, and the stone was later used for building in Wrightsville, including the office building at the bridge. Brownstone is quarried for local use at many places in the county.

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[24] Stose, G. W., op. cit., (Fairfield-Gettysburg folio, Pa.), p. 20, 1929.

Triassic diabase, or trap rock, makes excellent road material, but it is so hard and tough that quarrying and crushing is expensive. The rock crops out at many places in the area and makes Roundtop and other high hills in the vicinity. Large blocks of diabase were quarried at Yorkhaven (See Pl. 37 B) for use in the construction of the retaining wall for the hydro-electric plant. The coarse pink variety of diabase that occurs near Mt. Pleasant Schoolhouse, northwest of Nells Hill, and west of Yorkhaven, would make a pleasing building stone, and, because of its light and pleasing color, could be marketed as granite. Its thickness, extent, and fitness, however, have not been tested. It probably will take a high polish and be suitable for monuments and ornamental stone. The baked shale that borders the diabase throughout the area also makes a hard road material, but it does not bind readily.

Iron ore

Magnetite and hematite.—High-grade magnetite ore was formerly mined extensively in the vicinity of Dillsburg and Grantham. Ore has been mined from more than 30 openings 2 miles east of Dillsburg, and about 1,500,000 tons of ore was shipped in the 60 years of active mining begun about 1855. The mines were first described by P. Frazer,[27] who reported a hanging wall of trap in most of the mines which dipped 23° to 30° N. or NW., a footwall of sandstone, and bastard limestone (conglomerate) as much as 16 feet thick. The mines were later described in detail by Spencer.[28] The chief mines were the Logan, Cox, Price, Grove, Bell, Altland, Smyser, Longnecker, Underwood, and McCormick. The ore is a replacement of Triassic limestone conglomerate by solutions containing iron that emanated from the intrusive diabase. Garnet is associated with the magnetite. Although there has been no active mining of this ore for many years, it is believed that the deposits are not entirely worked out, and that exploration by modern methods may prove the presence of new or the extension of worked deposits.

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[25] Hopkins, T. C., Building materials of Pennsylvania: pt. 1, Brownstones: Appendix to Ann. Rept. State College, pp. 64-66, 1896

[26] Stone, R. W., Building stones of Pennsylvania: Pennsylvania Topog. and Geol. Survey, Bull. M 15, p. 301, 1932.

[27] Frazer, Persifer, Jr., Pa. 2d Geol. Surv. Rept. CC on York, Adams, Cumberland, and Franklin Counties, Dillsburg group of mines, pp. 207-239, 1877.

[28] Spencer, A. C., Magnetite deposits of the Cornwall type in Pennsylvania: U. S. Geol. Surv. Bull. 359, pp. 71-98, 1908.

On the south side of Yellow Breeches Creek, southwest of Grantham, magnetite ore was produced at three mines, the Landis or Fuller, Porter, and Shelby, which operated in 1860-1890. The ore is reported to be a replacement of Triassic limestone conglomerate, although mineralized Paleozoic limestone also is believed to be present in the mines and outcrops in the adjacent railroad cut. Prospects in mineralized Triassic conglomerate, 1 mile northeast of the old mines, show green andradite garnet with the magnetite replacing limestone pebbles.

One mile southwest of Dillsburg a small quantity of ore was produced at the Bender mine. The ore is believed to have been a replacement of limestone conglomerate adjacent to the intrusive diabase. Considerable garnet and pyroxene float is reported present in the soil.

At the Mine Bank workings, 2 miles southwest of Wellsville, micaceous iron ore in the form of a mixture of hematite and magnetite was mined in a series of pits and shafts extending about 1,000 feet along the strike of the Triassic rocks, parallel to and some distance east of the intrusive diabase contact. The presence of pieces of limestone on the mine dump suggests that the ore replaced a bed of limestone in the Triassic beds. The fact that a thin bed of limestone was observed by Bissell in the vicinity of Knalltown lends weight to this view. A narrow dike encountered in the mine workings may be the source of the iron solutions. The deposits were small and not much ore was shipped.

Hematite in small quantities occurs in places at the contact of the metamorphosed shale and diabase. It is especially conspicuous where a small dike leaves the bottom of the sheet of diabase 1 mile west of Yorkhaven. Here the sandstone is largely altered to epidote and hematite. The ore probably does not occur in commercial quantity. It has been mentioned that small quantities of hematite occur with the garnet in metamorphosed Triassic limestone conglomerate north of Yocumtown, and it also occurs in conglomerate at Erney.

Crystals of magnetite up to one-eighth inch in length are scattered through some of the ferruginous quartzites of the Chickies slate, Harpers phyllite, Wissahickon formation, and metabasalt. In places the magnetite is more concentrated and residual masses of good-grade magnetite ore may be found in the fields adjacent to the outcrops of these rocks, but ore of commercial value has not been developed. The only place in the area where this magnetite is known to have been prospected is a pit 1 mile north of Strickhousers, in ferruginous quartzite of Harpers phyllite. See footnote on page 189.

Ilmenite in small quantity occurs with the quartz that cements the brecciated pre-Cambrian rhyolite in Accomac Cove. It is of no economic value.

Limonite.—Limonite, or brown hematite, is a chemical combination of iron oxide with water. It is generally brown, but there are yellow and red varieties. It was precipitated, possibly as iron carbonate, from circulating underground water, especially at the contact of the Vintage dolomite and the underlying iron-bearing Antietam quartzite and also along faults that facilitated circulation of these waters. These deposits were worked for the most part in 1860 to 1880. They were described by P. Frazer, Jr.,[29] in 1876. At present none of the mines are active and the deposits are probably not now of commercial grade. They are of chief importance because of their geologic significance, since most of them are associated with limestone. In narrow valleys where limestone is not exposed because of its deep weathering and solution and the cover of soil, the presence of limestone is indicated by the iron ore. Limonite is commonly present along faults in limestone where circulating water has brought the iron to the surface and deposited it in the soil.

The uppermost beds of the Antietam quartzite are highly ferruginous, and iron ore accumulates as float in the soil and wash overlying the Vintage dolomite at the foot of the dip-slopes of Antietam hills. There is a line of old ore pits along the contact of the Antietam quartzite and Vintage dolomite on the south side of the Hellam Hills, beginning 2 miles west of Wrightsville and extending nearly to York, and on the north side of the Hellam Hills south and east of Emigsville. Some of these latter ore pits are associated with faults. The ore was shipped by rail and canal boat to furnaces at Marietta and Columbia. Extensive deposits of this type of ore have also been mined on the borders of the Antietam quartzite on the southeast side of the Pigeon Hills from southwest of Mt. Carmel School northeastward nearly to Nashville. Iron ore similarly associated with the upper beds of the Antietam has been mined also south of Jacobs Mills, 1½ miles north and 1½ miles west of Spring Grove, and 1 mile northwest of Stonybrook.

Iron ore has been mined also where the Antietam quartzite is overlain by Conestoga limestone in the Jefferson syncline, from Jefferson northeastward beyond Seven Valleys,* in the syncline south of Margaretta Furnace, in the East Prospect syncline west of East Prospect, southwest of Klein School, and south of Delroy, and in the syncline at Ore Valley. Ore occurs associated with the Conestoga limestone where Antietam quartzite is not present at the surface east of York Road and in the valley around Penn Grove and south of Iron Ridge. Iron ore was formerly mined at the contact of the Conestoga limestone and the Marburg schist northeast of Loganville. Some of these ores probably were concentrated by waters circulating along faults, especially along the Iron Ridge and Smith Station cross faults. Ore pits 1½ miles west of Mt. Carmel School, southeast of Gnatstown, near Iron Ridge, at Hobart, and east of Nashville also originated in faults.

In the South Mountain area, in western York County and adjacent part of Cumberland County, limonite has been mined at several places.

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[29] Frazer, Persifer, Jr., Pa. 2d Geol. Surv., Rept C on York and Adams Counties, for 1874-75, Description of ore banks, pp. 1-76, 1876. * See descriptive footnote on page 189.

On the north side of Dogwood Hollow a line of old ore pits extends for over a mile, and remnants of a furnace and ore washer still remain. In 1907 the Juniata Furnace and Foundry Co. of Newport, Pa., was operating one of the mines, and was reported to have an incline 275 feet deep and a 1,500-foot tunnel from the valley which tapped the ore below the surface workings. This deposit is along a fault between the Montalto quartzite and the Tomstown dolomite, and the wash on the lower slopes contains large masses of ferruginous chert and some iron ore. Another iron pit is located at the southeast foot of the mountain northeast of Stone Head. This is at a fault contact between the Antietam quartzite and Triassic diabase.

Red and yellow ochre, a form of limonite deposit, was mined for paint by John Kuntz half a mile west of Dillsburg, at the foot of South Mountain.

Copper

Signs of copper are not uncommon in the Triassic rocks of the region. Bright-green malachite, copper carbonate, has been observed as a coating on joints in the rock at several places in the county. Copper was prospected years ago 1¼ miles south of Zion View, at what was called LeCron's copper mine. Fossil carbonized wood and bones were obtained in the old pit and films of copper carbonate are plentiful in the material on the old mine dump. A fragment of carbonized wood 3 inches long, ⅜ inch wide, and 1/16 inch thick was collected by the writers. It is bordered by copper stain which also penetrates shrinkage cracks in the coal extending inward from the border. (See Pl. 21 A.) The deposit has no commercial value.

Ornamental stone

Rhyolite has been quarried locally for road material from a small opening just north of Highmount, on the farm of Albert Fahringer, but the rock is hard and brittle and possesses no binding qualities. The purplish-red variety, because of its attractive coloring, is suitable for ornamental purposes when polished. The quarry was purchased by Henry Billet, of New York, who polished blocks of the purplish rhyolite for monuments. Because of the irregular shapes into which the rock breaks in quarrying, the project was abandoned. There may be, however, a moderate demand for smaller pieces of the rhyolite in the manufacture of small articles, such as table tops, paper weights, ornamental boxes, and jewelry.

The coarse pink variety of diabase may be suitable for monuments and other ornamental stone, as stated under the heading Stone.

Garnet

Garnet is associated with magnetite in the old iron mines east of Dillsburg, but apparently is not in sufficient quantity to be of commercial value as abrasive. Small quantities of garnet occur also in the metamorphosed Triassic conglomerate near Yocumtown and Frogtown. Here it occurs in crystals of unique and rare form. (See Pl. 21 B.) They lack the color of gem stones but have a value as mineral specimens. The garnet crystals line cavities in the metamorphosed conglomerate where limestone pebbles have been dissolved, and 2 miles northwest of Yocumtown have been prospected by C. L. Huffer of Goldsboro.

Coal

There are persistent rumors that coal occurs in the Triassic rocks of the region, but none of commercial value have been found. Very thin films of coal have been observed by the writers at only two places in the county. In an old stone quarry, 1 mile northeast of Mount Wolf, irregular films of coal associated with fossil wood occur in a conglomerate at the base of the New Oxford formation. It occurs also at the Le Cron copper mine. The coal has no commercial value. Coal was also reported in wells dug in the New Oxford formation at Kohler Hill.

Coal is salvaged from the Susquehanna River by dredging, chiefly in the slack waters above the Holtwood dam. This coal consists of granules of anthracite brought down the river from culm piles at the mines in the northern part of the State at high stages of the rivers.

Oil and Gas

Oil or gas are not to be expected from any rocks in this area. However, a well was drilled for oil on the hilltop east of York New Salem. The well was sunk on an anticline of quartzite in the Chickies slate, north of the east-west road and half a mile east of the crossroads. No oil was obtained and the well was abandoned.

Water Supply[30]

The city of York requires a large supply of pure water for its population and extensive industries. A bountiful supply of pure soft water is obtained from Codorus Creek in the hills south of the city. A dam on the East Branch of Codorus Creek, 1 mile west of Jacobus, ponds a large body of water called Lake Williams, the upper end of which reaches Highway 111. The slopes of the hills surrounding the lake are protected by a dense growth of evergreens through which the highway passes. The pumping and filtration plant is lower down on East Branch. A distributing reservoir on Violet Hill, 1½ miles south of York, is over 200 feet above the city.

Hanover has a reservoir at several large springs in a ravine on the south side of the Pigeon Hills, 1 mile east of the road to Abbottstown. This water supply was not adequate for the growing industries of the city, and a larger quantity of soft water is now obtained from the Shepard Morris reservoir, 5 miles south of the city, where a dam on the South Branch of Conewago Creek, 1 mile southwest of Bandanna, ponds the water of the creek. Evergreen trees were planted in 1937 on the slopes of the hills in the vicinity of this reservoir. Four wells in the town, from 415 to 550 feet deep, supply ice, creamery, and electric light plants with water. It comes from the Conestoga limestone and is therefore hard.

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[30] Hall, George M., Ground water in southeastern Pennsylvania: Pa. Topog. and Geol. Survey Bull. W 2, pp. 235-241, 1934.

Wrightsville obtains its water from Kreutz Creek, which heads in the hills south and north of the limestone valley, and empties into Susquehanna River at the south edge of the town. Hellam gets its water from the head of Kreutz Creek in the hills north of town. Red Lion and Dallastown have a reservoir near the headwaters of Cabin Creek, just below Locust Springs. A small distributing reservoir is on the hill southeast of Dallastown. Spring Grove obtains its water from Codorus Creek, which is ponded southwest of the town. The P. H. Glatfelter Company in Spring Grove drilled several wells in 1936 and 1937 in the valley south of the town to obtain an adequate supply of pure soft water for its paper mill, and constructed a new reservoir just below the Hanover road. Glen Rock obtains its water from the South Branch of Codorus Creek, which flows through the town.

Dillsburg's water supply is piped from South Mountain. Two wells in the borough, 200 and 300 feet deep, supply the Hershey Creamery Co. with an ample supply of soft water. The water comes from the Gettysburg shale. Emigsville's water supply is from springs in the hills of Cambrian quartzite northeast of the hamlet. Yorkhaven uses the water of Susquehanna River just above the borough. Marietta, in Lancaster County, has its water supply piped under the river from its source in the Hellam Hills in York County.

Dover gets its water from a drilled well, 8 inches in diameter and 310 feet deep, in Triassic sandstone. The water is pumped to a cylindrical tank 20 feet in diameter and 20 feet high, and standing 100 feet above the ground. Some of the smaller villages obtain their water supply from small reservoirs on nearby streams, but most of them depend on individual wells. The deepest known well in the county is at the tannery in Wellsville. It is 741 feet deep, 8 to 6 inches in diameter, and yields 40 gallons per minute. Other recorded deep wells are as follows:

V. Poteheiber, Yocumtown, Triassic sandstone, 120 feet deep, 6 inches diameter, 10 gallons per minute.

City Dairy Co., 1¼ miles northwest of Yocumtown, Triassic sandstone, 150 feet deep, 6 inches diameter, 100 gallons per minute. Limestone? (probably limestone conglomerate) reported at bottom.

Water Power

The Susquehanna is one of the most important water-power streams in the eastern part of the United States, and from its headwaters in Broome County, N. Y., to Havre de Grace, Md., where it enters Chesapeake Bay, it flows through a busy industrial district. The power available 50 percent of the time in a 20-mile stretch of the river above Columbia is about 90,000 horsepower. The river lies chiefly in Dauphin and Lancaster Counties, as the county line is at or near the west shore.

The only water-power development on the Susquehanna in York County is the plant of the Metropolitan Edison Co. at Yorkhaven. (See Pl. 8.) The water in the river is diverted to the head gates of the power plant on the west bank by a low dam extending diagonally across the west channel of the river to Threemile Island and across the east channel to the east bank of the river about 1 mile above Falmouth. The capacity of the installed water wheels is about 20,000 horsepower operated under a head of about 22 feet.

A large hydro-electric plant was completed in 1931 at Safe Harbor, in Lancaster County, about 11 miles below Columbia. The dam is 92 feet high and, including the power house, is over a mile long. Backwater from the dam extends to Columbia. Two great hydro-electric systems lie below Safe Harbor, the older one at Holtwood, Pa., and the newer one at Conowingo, Md. With the completion of the plant at Safe Harbor, the power resources of the Susquehanna River below Columbia are completely developed. The capacity of these three plants is about 1,250,000 horsepower. (See Pl. 38.)

A few grist mills are located along Conewago, Little Conewago, Yellow Breeches, Codorus, and Muddy Creeks, where power is obtained from the dammed streams. At Lisburn a dynamo operated by the water power from the creek supplies electric light and power to the village.

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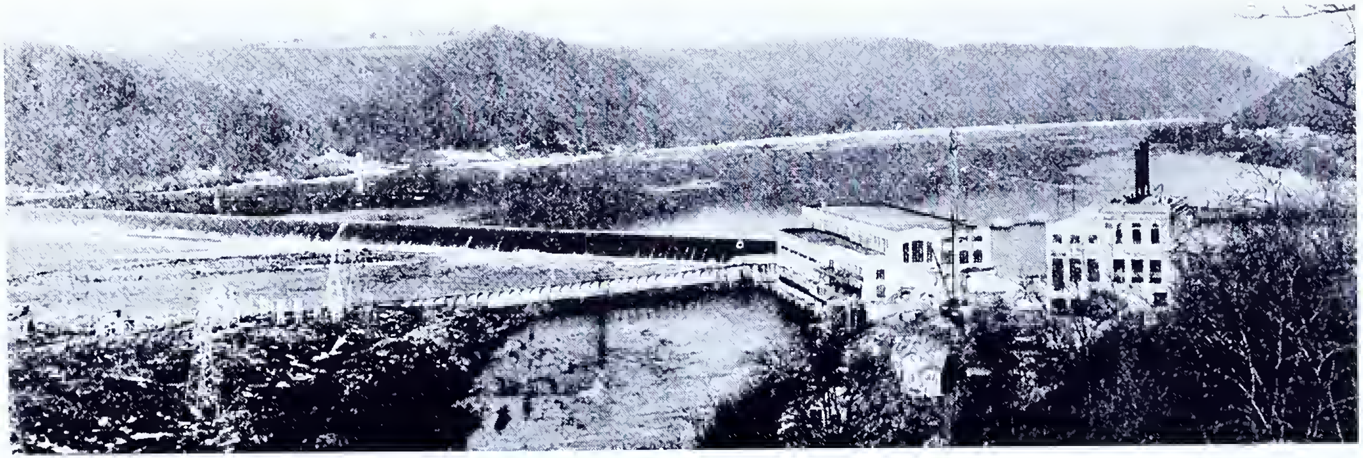
* Footnote:

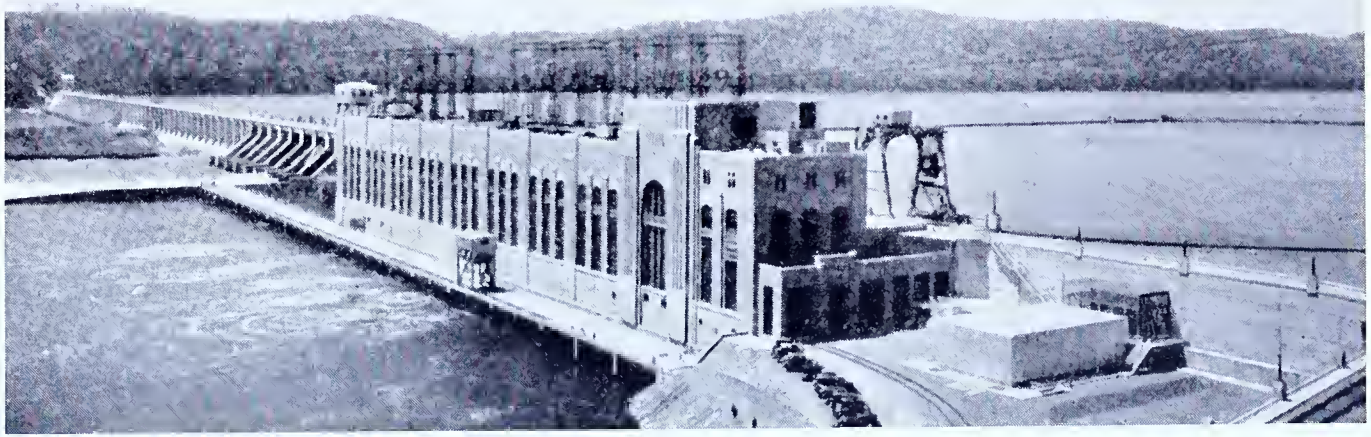
The ore formerly mined in 15 pits along a narrow belt, extending parallel to the Western Maryland R. R., from Sinsheim through Jefferson to Hanover Junction, is largely specular hematite and magnetite, and is known as Codorus ore, from the old Codorus, or Strickhouser, mine of the York Iron Co. The ore is a partial replacement, or enrichment, of slate adjacent to the Martic overthrust. Blue clay and limestone were exposed in some pits and the slate and limestone are believed to be Conestoga. Some of the quartzose ore may be in schistose Antietam quarzite. The mines are described by Persifor Frazer, Jr., in Rept. C of the Pennsylvania 2d Geol. Survey on York and Adams Cos., pp. 28-35, 1876. The average analysis of the ore is reported to be as follows:

Siliceous matter	32.400
Metallic iron	34.375
Phosphorus	.378
Undetermined	32.847
	100.000

Some magnetite ore ran as high as 46 percent metallic iron, and phosphorus as high as 2 percent.



A. Hydro-electric power dam on Susquehanna River at Holtwood, Lancaster County.



B. Hydro-electric power dam on Susquehanna River at Safe Harbor.

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